ENGINEERING NEWS

Vol. XLVIII. No. 13.

TABLE OF CONTENTS.

(24 *pages; no inset.*)

ENGINEERING NEWS OF THE WEEK..... 225
The Water-Power Plant of the Michigan-Lake Superior Power Co., at Sault Ste. Marie (illustrated).. 226
Convention of the American Electrochemical Society 228
Notes from the Engineering Schools..... 232
Handling Fuel Oil at Railway Terminals..... 232
Paving a Country Road with Brick (illustrated)... 233
Report on Water-Works Rates and Valuation at San Antonio, Tex.... 233
Traction Engine Practice and Manufacture in the United States 234
The Recent Development of Tool Steel..... 234
Difficult Work in Repairing a Swiss Railway Tunnel (illustrated) 235
Telephone Tunnels and Automatic Telephone-Exchange System at Chicago. 239
Progress in Steel-Works Practice in Germany Since 1880 240
The "Kaiser Wilhelm II.," the Longest Steamship Ever Constructed (illustrated) 241
High-Pressure Water Supply System, for Fire Protection in Chicago 242
The New York Rapid Transit Ry. XI.—Inspection of Cement 242
Unit Stresses and Impact in Old Railway Bridges.. 244
Surmounting Great Ascents in Waterways (illustrated).... 245
An Engineering Commission on the Artesian Wells of the Memphis Water-Works (illustrated)..... 245
Early Studies of the Artesian Well System of Memphis (illustrated) 248
EDITORIAL NOTES..... 236
The Advantages of Electric Power for Mine Pumping—Inadequate Salaries for Engineers in the New York Building Department—The Safe Limit of Height of Fall in Pile Driving—The Increase in the Use of Pneumatic Tools—A Remarkable Locomotive Performance.
EDITORIAL:
The Price Contractors Charge for Carrying Risks.. 237
LETTERS TO THE EDITOR 237, 238
Concrete Reinforced with Expanded Metal for Permanent Bridge Floors—Reheating Between the Cylinders of Compound Engines—Calculating Columns Under Eccentric Loads—The Present Status of the Sewage-Disposal Problem in England—Primary and Secondary Considerations in the Disposal of Sewage, Continued—Engineers, Contractors and Specifications—Concerning the Compensation of Engineers—Notes and Queries.

THE IRON ORE SHIPMENTS from the Lake Superior region in August reached a total of 4,078,311 long tons, exceeding the shipment of August, 1901, by 476,306 tons. Up to Aug. 31 the season's shipment amounted to 17,051,330 tons, a gain of 4,788,094 tons over the same period of last year. With two months of open navigation to be counted, the shipment for the whole season of 1902 will exceed 25,000,000 tons.

IRON AND STEEL SLAG is discussed by Mr. E. C. Eckel in the forthcoming "Mineral Resources of the U. S., 1901." The most important of the uses of slag is in the manufacture of structural material and especially hydraulic cements. The production of the six or eight slag-cement establishments in 1901 amounted to 272,689 barrels; and two plants are making Portland cement from slag and limestone. The highly phosphatic slags produced in basic Bessemer converters are valuable fertilizers, and Germany sells large quantities of this product under the name of "Thomas silicate." Here this product is of less commercial importance owing to the slighter development of the basic Bessemer steel industry; only about 1,000 tons of American phosphatic slag were sold for fertilizers in 1901. Mineral wool is also largely derived from slag; though about one-half of that sold is made from natural rocks of different types. In 1901, 3,500 tons of mineral wool were made from slag in the United States. In the year about 5,000 tons of slag were used in constructing macadam highways, and have proved entirely satisfactory in various states.

THE TONGE HYDRAULIC MINING CARTRIDGE, invented by James Tonge, of Westhoughton, Lancashire, England, is intended to break down coal in mines without the use of explosives. This cartridge consists of a steel cylinder 20 ins. long and 3 ins. diameter, having eight small duplex rams fixed radially along the cylinder. By a suitable arrangement of passages a communication is made between each of these rams and simultaneous action can be secured. By an ingenious contrivance a greater traverse is given to these rams than the diameter of the cylinder would appear to allow. Thin liners are used to prevent the rams cutting into the coal. Power is supplied by a hydraulic pump of special design, and 1½ pints of water are required for one operation, though most of this water returns to the tank and can be used again. A pressure of 3 tons per sq. in. can be reached, or a total pressure on the coal of over 60 tons, which is sufficient for an ordinary seam. The cartridge is applied by drilling a 3¼-in. hole, 3 or 4 ft. deep, parallel with the roof and as near as possible to the natural parting in the coal. The cartridge is put in with its liners and pushed to the back of the hole, and the pump-pipe is then connected and pumping commenced. On a "long-wall" face, one cartridge and one man can make 150 "thrusts" per week, at a total cost of £5 4s. 9d.; this will give about 300 tons of coal, with 75% "round" coal. On the same face a man working with explosives would make 150 "shots" at a cost of £5 5s. 6d., and obtain 300 tons of coal, but only 65% would be "round" coal, and the one cartridge, under like conditions, would show an advantage of £15 per week, particularly in the increased value of the coal. The hydraulic cartridge has been used for two years in the Chequerbent and Atherton collieries in England. The chief advantages claimed are: Absolute immunity from explosions, no shaking of roof, absence of poisonous fumes, larger coal brought down, economy over explosives.

A LARGE CHARCOAL BLAST FURNACE is described in a recent number of "Stahl und Eisen." This furnace has been built at the Vareser Eisenindustrie Aktien-Gesellschaft at Vares, in Bosnia, where iron has been manufactured for many years. It is 21.25 m. (70 ft.) high, and has a diameter varying from 2½ to 4½ m. (8¼ ft. to 14 ft. 11 ins.). It is provided with a hot blast stove in which the blast is heated to 850°. The charge consists usually of 40% hematite and 60% brown ore of the following composition:

	Hematite.	Brown ore.
Metallic iron	40.4	57.7
Manganese	11.3	6.2

The combined charge has from 0.02 to 0.03 phosphorus and from 0.01 to 0.06 sulphur. The average yield from the charge is 53% in pig iron. The highest output of the new furnace has been 3,270 tons in one month, with an average consumption of 770 lbs. of charcoal to 1 ton of iron.

A COMBINED WATER POWER AND WATER SUPPLY development is projected at Catskill, N. Y. It is proposed to impound the waters of Kaaterskill Creek to form a lake with an elevation of 325 ft., which will furnish sufficient storage to equalize the flow of the stream throughout the year. With ultimate development, it is estimated that some 4,000 HP. can be procured, and an immediate market exists for it in neighboring towns and villages, and in the city of Hudson, just across the Hudson River. From the water thus stored a supply of potable water of high excellence may be furnished to the villages of Catskill and Athens, which now pump their supply from the polluted Hudson. The project is in the hands of the Lake Kiskatom Water-Works & Electric Power Co., of which Jas. H. Van Gelder, Esq., is the Manager, and capital is now being enlisted to carry out the works.

WATER-WASTE STUDIES AT COLUMBUS, O., made by means of the pitometer by John A. Cole & Son, of Chicago, indicate a night waste of about 4,800,000 gallons daily. The engineers also concluded that some 5,000,000 gallons per day of pump slippage could be saved by needed repairs, and 1,000,000 gallons addition by changes in the condensers. They recommend a more detailed investigation. The indicated pumpage in July, 1902, it may be added, was at the rate of 19,975,000 per day, but of this 7,560,000 never reached the distribution system, for the reasons stated above.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a butting collision between two passenger trains on the Pittsburg & Western Ry., at Witmer, Pa., on Sept. 19. Five persons were killed and several injured. The collision was due to the fact that the line was temporarily run single track at that point, and to somebody's neglect to properly arrange for the trains to pass.

A BURNOUT ON A TROLLEY CAR in the Brooklyn section of New York city caused injuries to a number of persons on Sept. 21. It appears that a short circuit occurred in the controller, which set the car floor on fire.

THE BREAK IN THE RESERVOIR EMBANKMENT at Utica, N. Y., on Sept. 16, noted briefly in our last issue, is reported by the Utica "Press" as being from 100 to 150 ft. across, measured along the top, and as extending nearly to the bottom of the 70-ft. embankment. On the morning of Sept. 13, a landslide occurred on the outer slope, a mass of earth some 50 ft. wide and 5 ft. deep, and extending about half way up the bank, sliding down to the toe. The next morning another slide took place, and cracks appeared for a length of 125 ft. along the top of the embankment. On the morning of the final collapse a part of the top of the structure, extending to the slope paving, slid down. During the forenoon other masses of earth fell from time to time. At 1.54 p. m. water spurted through a hole near the top of the embankment, and a little later through a second hole. Soon the two streams joined and for a "brief period the earth above held its place, forming an arch above the rapidly-growing stream." Of course, this condition did not last long. The arch fell and the sides of the channel crumbled more and more rapidly until the break extended to its full width. Directly after the first landslide, all available channels for emptying the reservoir were thrown open, but the water had been lowered only some 8 ft., it is said, and the volume reduced by perhaps one-third, when the great break came. The property damages below appear to have been scattered, and comparatively small at any one place. Mr. W. S. Bacot is Engineer and General Manager of the Consolidated Water Co.

COAL-MINING ACCIDENTS IN 1901 are reported upon by Mr. E. W. Parker, for the forthcoming "Mineral Resources of the U. S. 1901." In 18 states and territories 1,467 lives were lost in 1901, and 3,643 men were injured in coal mining. For each life lost the number of tons mined varied from 426,004 in Maryland to 49,424 in Indian Territory. The total number of men employed in these coal mines was 485,544; of these 145,309 worked in the anthracite mines. In the Pennsylvania mines, 513 men were killed and 1,243 injured in the anthracite mines, and 301 killed and 656 injured in the bituminous mines.

AN ELECTRICIAN'S SAFETY-DRESS has been invented by Prof. Artemieff, and it was lately tested in the high-tension laboratory of Siemens & Halske, says "Engineering." The dress is composed wholly of fine but thickly-woven wire gauze, completely enclosing the wearer, including hands, feet and head. It weighs 3.3 lbs., but its cooling surface is so great that a current of 200 amperes can pass through the dress from hand to hand for some seconds without perceptible heating effect. Standing on the ground, uninsulated, Prof. Artemieff drew sparks from the secondary terminals of a transformer which was giving a tension of 75,000 volts, with a period of 50 cycles per second. The inventor concluded his experiments by short-circuiting a generator of 170-K-W. capacity by clutching hold of the terminals, the potential difference between the two being 1,000 volts, and the current passed 200 amperes. Throughout the experiments Prof. Artemieff declared that he did not feel the slightest sensation of a current passing through his body.

ELECTRIC TRAINS on the Wannsee Railway, near Berlin, have been discontinued, as the operating expenses were as great as in the case of steam locomotives. This is probably due to the fact that the electric trains were sandwiched between the steam trains. The German State Railway authorities will make another experiment next July, with electric trains alone, between Potsdam and Gross Lichterfeld. They will use trains composed of three motor cars, carrying 206 passengers.

THE U. S. PROTECTED CRUISER "DES MOINES" was launched at Quincy, Mass., from the Fore River yard, on Sept. 20. This protected cruiser was authorized by Congress March 3, 1895, and the keel was laid Aug. 28, 1900. She is 292 ft. long on water line, 308 ft. 2 ins. extreme length, has a beam of 44 ft., normal displacement of 3,200 tons, full load displacement of 3,500 tons; with 4,700 I. HP. her estimated speed is 16½ knots. The "Des Moines" is unarmored, and will carry ten 5-in. r. f. guns, eight 6 pdrs., two 1 pdr. and four Colt automatic guns. The 100 water-tight compartments are protected by 6,720 cu. ft. of corn-pith cellulose, packed between the outer and inner skin of the ship. She will have a crew of 30 officers and 263 men, and is especially fitted for cruising in tropical waters.

THE AIR-SHIP OF STANLEY SPENCER, the English aeronaut, ascended from the Crystal Palace, in London, on Sept. 19, and made a trip of nearly 30 miles, seemingly under perfect control as to direction. This exceeds by 20 miles the longest trip of Santos-Dumont. The Spencer air-ship has a blunt nose and tail, and the bag is 75 ft. long containing 20,000 cu. ft. of gas. The frame is bamboo and the propeller is in front. The motor is a petroleum engine of 30 HP., with the machinery controlled by electricity. It weighs 600 lbs. and carries only one person; special devices prevent dipping and pitching.

PROGRESS ON THE SIMPLON TUNNEL for August is reported in the "Schweizerische Bauzertung" as follows: "The advance of headings during the month was 1,102 ft., of which 512 ft. was in the north end, 590 ft. in the south end. The total length of heading driven by the end of August, 1902, was, therefore, 42,361 ft. total, or 25,354 ft. in the north end and 17,007 ft. in the south end. During August the north heading progressed through slaty gneiss, the south end through calcareous mica schist veined with quartz. Work was stopped during the month for two periods aggregating 36 hours, 12 hours of this being for alinement work and 24 hours' stop for a holiday.

THE COMMERCIAL ORIENTAL EXPEDITION CO., of Seattle, Wash., proposes to send a steamship from Seattle on Nov. 15, 1902, on a six-months' tour of the East. The purpose of the trip is purely commericial, the route being selected with a view of enabling the representatives of American business houses to test trade and to establish permanent agencies. The lower deck of the steamship is fitted for exhibition purposes, and will be electrically lighted. Mr. S. G. Simpson is President, and Mr. Alfred Rimmer is Business Agent, both of Seattle, Wash.

THE WATER-POWER PLANT OF THE MICHIGAN-LAKE SUPERIOR POWER CO., AT SAULT STE. MARIE.

One of the largest pieces of engineering work in the United States is the water-power plant which has just been completed at Sault Ste. Marie, Mich., after four years of work. We described this enterprise in full detail at the time it was first undertaken in 1898,* and in our issue of Jan. 9 last, in a general article upon the engineering works at the Sault, we reported the progress made at that time in the hydraulic power enterprise.

We give herewith a number of views of the works, reproduced from photographs, for which we are indebted to the courtesy of Mr. H. Von Schon, Chief Engineer.

As most of our readers are aware, the Sault de Ste. Marie (or St. Mary's Rapids, to use the English translation), is the outlet of Lake Superior, the largest body of fresh water on the globe. The rapids are formed by the fall of the waters over a ledge of sandstone rock about half a mile in width. The total fall of the rapids is about 20 ft. and they continue for about a half-mile. The total area of Lake Superior is some 30,000 sq. miles, and the discharge varies from 3,000,000 to 7,000,000 cu. ft. per minute. The flow varies according to the level of the lake, which is influenced not only by its varying stage at different seasons, but by the prevailing winds. The total available HP. of the water flowing over the Sault Rapids is from 130,000 to 260,000 HP. With the completion of the new power canal on the American side, more than half of this available power is harnessed for industrial purposes. Besides its use for power, the flow from the lake is made use of for the lockage of vessels passing up and down the canals on either side of the rapids. While this article relates to the power development, it may be noted in passing that, through the locks on each side of the rapids, during the season of navigation the largest fleet of merchant vessels in existence passes up and down.

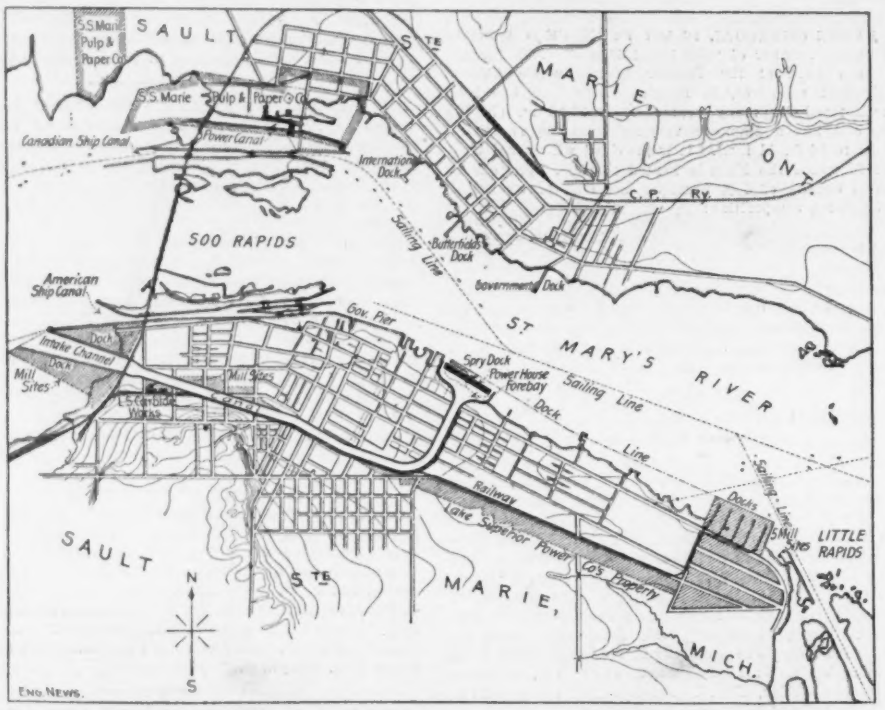


FIG. 1. MAP OF SAULT STE. MARIE, SHOWING WATER POWER CANALS OF THE LAKE SUPERIOR POWER CO. (Reproduced from Engineering News of Aug. 4, 1898.)
Francis H. Clergue, President and General Manager; H. von Schon, Chief Engineer.

The possibilities of power development at the Sault have long been attractive to promoters and investors and in the years from 1885 to 188[illegible] an attempt was made to exploit them by the St. Mary's Falls Water Power Co. Financial difficulties, however, caused the wreck of the enterprise. The chief obstacle to commercial development was to find a market for the power at a point so remote from any center of population or industry. Electrical transmission was, at that day, practically unknown, and even in the present state of the art the Sault is by far too remote from any city to render the electric transmission of its power practicable. As for the use of power for ordinary manufacturing purposes, it has come to be well understood that in almost all manufacturing industries the cost of power is too small a factor to justify a location that is for other reasons undesirable. Practically, therefore, the development of the power of this place, w[illegible] fectly feasible as an engineering proposi[illegible] commercially impracticable until the deve[illegible] of the new electro-chemical industries c[illegible] demand for cheap power in great quanti[illegible]

On the Canadian side, local capitalists [illegible] took a canal in 1891, but were unable to [illegible] to completion in the season of financial [illegible] which soon followed. In 1894, the Lake S[illegible] Power Co. undertook the development of [illegible] on both sides of the Sault, obtaining all the [illegible] ter rights of the former unsuccessful enter[illegible] It carried to completion first a 20,000-HP. [illegible] on the Canadian side, using the power for [illegible] manufacture of paper pulp. On the American [illegible] a market appeared for the power in the new [illegible] dustry of manufacturing calcium carbide, a [illegible] tract for 20,000 HP. being closed not long after the company was organized. The second [illegible] has been put under construction on the Canadian side, a map of which was shown in our issue of January 29, 1902; and it will develop, when completed, about 50,000 HP.

It will, of course, be evident that the flow of water through these large canals constitutes an additional draft upon the water of Lake Superior, and if the flow through the St. Mary's River were left unaltered the level of the lake would soon be lower. This would not only seriously interfere with navigation and reduce the depth of water in the locks, but would also reduce the flow through the canals. To compensate for the water taken by the canals, therefore, the government has required the company to carry a dam part way across the head of the St. Mary's River. This dam extends out from the Canadian shore about 2,000 ft. At a point near the shore, controlling works have been erected by which the volume of water drawn from the lake may be regulated. These works are shown by Figs. 9 and 10. They consist of heavy masonry piers between which are operated four Stoney sluice-gates, each 48 ft. in width and 15 ft. high. A great deal has been published concerning the project for controlling the level of Lake Erie by works erected at the head of the Niagara River, and there has been some popular skepticism as to the possibility of effectually carrying out such works. It is worth noting that the works just described at the outlet of Lake Superior are an example of what can be done with simple and well-known means in the control of even the greatest bodies of fresh water.

Turning now to the canal on the American side: The original plans for this proposed a straight channel from the lake above the rapids to a point below; but before construction was undertaken this was changed to a curved location (shown on the map, Fig. 1), considerably shortening the length of the canal. The contracts were awarded for the work in October, 1898, to the following parties: H. W. Hubbell & Co., West Bay City, Mich., for the intake; the E. D. Smith Co. of Philadelphia, for the building of the canal; the Mason & Hoge Co., Frankfort, Ky., for the forebay and power house. The intake to the canal is located just south of the entrance to the United States Ship Canal, and is some 950 ft. in width at the head. The portion under water was located in a shallow bay, generally 3 to 5 ft. deep, and ex-

FIG. 2. VIEW NEAR ENTRANCE OF CANAL, LOOKING TOWARD THE INTAKE.
(View Taken Before Removal of Cofferdam at Entrance of Canal.)

*Engineering News, Aug. 4, 1898.

avation was required for a distance of about 400 ft. Cofferdams were built and the rock under water was excavated under their protection. The sand and gravel in the channel were removed by dredging.

At a point 1,000 ft. from the entrance to the lake the channel narrows to a width of 250 ft., and thence continues at this width to the head-gates of the canal, which are shown in Fig. 3. The excavation where these head-gates are located is in solid rock. Three masonry piers were built in the canal and the four openings thus made are controlled by Stoney sluice-gates, each 48 ft. wide and 26 ft. high. From these gates to the forebay the canal is about 9,000 ft. in length, its general course being easterly for 6,000 ft. and then turning at a right angle to a northerly course toward the forebay. The depth of the canal below the water level is 23 ft.

FIG. 3. HEADGATES AT ENTRANCE OF CANAL.

The material through which the canal was excavated was, as already stated, sand, boulders and gravel in the intake for some 1,500 ft., then 4,000 ft. of sandstone rock, then a second formation of drift sand and boulders for some 2,000 ft., and then a formation of siliceous clay, which continues to the power house. As the canal flows for a considerable distance through the city of Sault Ste. Marie, it was necessary that its banks be made secure and also that its width be kept at a minimum. At the intake the sides of the canal are confined by timber cribs carried up to a point just below the water level and then topped with masonry construction. Through the rock formation the canal sides were cut with vertical channeling machines in the same manner as was done on the Chicago Drainage Canal. Any seams or faults in the rock after excavation were made smooth by masonry construction.

Fig. 5 shows the point where the canal passes from rock into sand and the vertical walls are changed to slopes of 1 on 1. In the section in clay (shown in Fig. 6) the cross-section of the canal is changed to a semi-ellipse with the sides having three different slopes; the top, 1 on 1; the next, 1 on 4, and the last 1 on 10. A remarkable and, so far as we know, wholly unprecedented feature of the construction of this canal is the lining of the sections excavated through sand and clay with timber planking, not only on the slopes but on the bottom. The object in doing this was to enable a velocity for the water through the canal to be adopted under which sand or clay would be subject to rapid erosion. This timber covering is formed by driving piles in rows spaced 5 ft. apart, running transversely across the canal. To these are secured timber sills faced to a uniform width of 12 ins. and fastened to the piles by drift bolts. The planking is laid on these sills and is of 3-in. thickness and 4-in. width. This timber construction is stopped at a point below the water level and the slope above this is of stone paving at a slope of 1 on 1. It will be noted that this construction secures a perfectly smooth section throughout the canal and decreases the friction of the flowing water, a matter of considerable importance with so long a canal having so low a head to utilize for power.

FIG. 5. VIEW OF CANAL AT CHANGE FROM ROCK TO EARTH SECTION.

The cross-section below the water line is 4,800 sq. ft. in the intake, 4,600 sq. ft. in the rock channel and 4,300 sq. ft. in the timber-lined sections. With the power house running at its full capacity, the velocity of flow in the canal will be about 4½ miles per hour (6.6 ft. per second), delivering approximately 30,000 cu. ft. of water per second to the turbines and enabling the power house to deliver about 60,000 HP.

At the lower end of the timber-lined section, as shown on the map, Fig. 1, the canal widens into a forebay 1,400 ft. in length. The lower side of this forebay is closed by the power house (shown in Figs. 7 and 8), which, in fact, constitutes a dam. This power house is built on pile foundations, some twelve thousand 50-ft. piles having been driven through the clay to the rock. Their tops were capped and they were covered with a floor of concrete 3 ft. thick. Underneath the power house are eighty-one chambers 100 ft. in length and 20 ft. high, separated from each other by 3-ft. masonry walls. They are open on their lower side to the St. Mary's River, and receive the discharge from the turbines. The floors and roof of these chambers are monolithic concrete arches. Above these pits are eighty-one chambers opening on the up-stream side, each 15 ft. wide, 45 ft. long and 20 ft. high, in which the turbines are placed. These chambers are divided from each other by steel and concrete partitions, and they are closed on the down-stream side by semi-circular steel plate bulkheads opening on top. On the other side of this partition is the generator room. Each hydraulic unit is made up of four 33-in. New American turbines, arranged in two pairs on one shaft. Each pair is housed in one case and discharges into a single draft tube. The shaft from the turbines passes through the steel plate bulkhead to the generator room. Each hydraulic unit is designed to use 391 cu. ft. of water per second at an effective head of 16 ft. and to develop 568 M. HP. The efficiency of these turbines is from 81% to 82%, according to tests made prior to their acceptance. Each hydraulic unit drives a 400-KW. generator. Both alternating and direct-current machines have been installed and were furnished by the Westinghouse and Stanley companies.

FIG. 4. CANAL EXCAVATED THROUGH ROCK. (Length of Rock Section, 2,700 ft.; Normal Width, 200 ft.; Cross-Section Below Water Level, 4,400 sq. ft.

Above the generator room the power house has two additional floors extending for its entire length. The walls of the house are of sandstone excavated from the rock section of the canal. It has steel roof trusses covered with galvanized corrugated iron.

At the point where the canal widens into the forebay (shown in Fig. 7) is located a steel trestle work which supports the racks for intercepting floating debris and anchor ice. The entire work has involved the excavation of 1,250,000 cu. yds. of rock and 3,000,000 cu. yds. of earth. The material excavated was used in reclaiming lands under water owned by the Lake Superior Power Co. In building foundations there were driven 3,500,000 linear ft. of piling, and the masonry work includes 170,000 cu. yds. of concrete, 900,000 cu. yds. of sandstone masonry, and 32,000 sq. yds. of dry sandstone paving. The excavation was carried on with an equipment of eight steam shovels, 24 locomotives and 350 4-yd. dump cars. All the work has been carried on night and day continuously, with the exception of Sundays. The approximate cost of the entire right-of-way, canal, power house, equipment, docks and appurtenant works is about $4,000,000. Mr. H. von Schon has been the Chief Engineer of the Michigan-Lake Superior Power Co. since the works were inaugurated, and deserves much credit for the manner in which they have been carried to a successful completion.

CONVENTION OF THE AMERICAN ELECTROCHEMICAL SOCIETY.

The second general meeting of the American Electrochemical Society was held at Niagara Falls, N. Y., on Sept. 15 to 18, inclusive. With an attendance of nearly 200 members and guests and a technical program comprising about a score of papers, the meeting was of equal rank with the conventions of any of the old-established large national societies of American engineers.

It will be remembered that this society was formed less than six months ago. Some 350 members enrolled at once, and at the first meeting, held at Philadelphia, Pa., on April 3 to 5, 1902, so many papers were offered that the new society was unable to handle all of them. This promising state of affairs, certainly unusual for a society just beginning its life, indicated that there was a widely-felt need for just such a society. That need resulted from the great growth of the application of electricity to chemical, metallurgical and related processes, and also from the rapid growth of the science of physical chemistry on its electrochemical side. Both theoretical and practical workers felt that they had developed beyond their respective parent fields of physical chemistry and electrical engineering, and they therefore felt a need for a meeting place where they could cultivate their own distinctive science, electrochemistry.

The same condition exists also in other countries; in Germany a society of similar aims is in the first years of its existence, while in England a movement to form an electrochemical society is at present under way. It will not be a matter of surprise, therefore, that the formation of the American Electrochemical Society aroused considerable interest in Europe, and that a number of English and Continental students of the science have joined the society as members. One of these foreign members, Herr Prof. Dr. F. Haber, of Karlsruhe, Germany, who is also a member of the German sister society, the "Deutsche Bunsen Gesellschaft," was a visitor at the present convention. He brought to the society the greetings and good wishes of the "Deutsche Bunsen Gesellschaft" in the form of a letter from its president, Prof. Van 't Hoff, and was in turn commissioned by the American Electrochemical Society to take back with him the compliments of the society to its German sister organization.

The present convention was wholly a technical meeting, since the election of officers and other annual business will be transacted at a general meeting to be held next spring. The convention lasted the four days from Monday to Thursday, Sept. 15 to 18, inclusive. Sessions were scheduled to be held on the morning of each day; in addition, an interpolated session was found necessary, and it was made possible by omitting a picnic on the program for Wednesday afternoon. A few small matters of society business came up during the meeting, as follows:

At the beginning of the Monday session, the secretary, Mr. C. J. Reed, reported that the society now had 418 members, and that there were several applications for membership on file. Mr. P. G. Salom, the treasurer of the society, reported on the state of its finances; it appeared that there was a clear amount of about $950 on hand.

At the Wednesday meeting, Prof. W. E. Goldsborough, of Lafayette, Ind., director of the department of electricity at the Louisiana Purchase Exposition, addressed the society on the subject "Electrochemistry at the World's Fair, St. Louis." The speaker described the layout of the exposition grounds, and the superior advantages of the St. Louis fair over preceding ones in the way of available funds, location, etc. He then made a strong appeal for the coöperation of the American Electrochemical Society, collectively, and its members, individually, in building up a large and representative exhibit in electrochemistry. One remark in the course of the speech deserves to be recorded here. In arguing for a strong exhibit of electrical matters generally, Prof. Goldsborough put forward the assertion that the St. Louis fair would probably be the last one at which electricity would have the opportunity of forming a separate department; the next great world's fair, he said, would be entirely an electrical exhibition, with subordinate departments for mechanical engineering, civil engineering, etc.

FIG. 6. VIEW OF TIMBER-LINED CANAL ON 3° CURVE, THROUGH CLAY.
(Section of Prism, Semi-Elliptical; Width at Water-Line, 214 ft.; Cross-Section Below Water-Line, About 4,600 sq. ft.)

At the close of the address a resolution was adopted that the society as a body give Prof. Goldsborough its aid in forming a strong exhibit of electrochemistry at the St. Louis fair.

It was brought to the attention of the society that in June of 1903 the Fifth International Congress of Applied Chemistry will be held in Berlin, Germany. Dr. H. W. Wiley, of the U. S. Department of Agriculture, has been asked to organize an American section to take part in the deliberations of this Congress, and the society was requested to give its aid in this work. The matter was referred to the directors for consideration.

At the close of the session on Thursday the society adopted resolutions of thanks to the committee of local members, the ladies' committee, and the different industrial concerns at Niagara Falls, which, as noted below, had extended courtesies to the society. Adjournment was then taken until the annual meeting in spring, which will be held during the Easter holidays. An invitation was extended to the society on the part of the New York members to hold this annual meeting in New York city; the invitation was referred to the directors for consideration, and it is probable that it will be accepted.

Niagara Falls is the city of the whole world where electrochemical industry has developed on the largest scale, and in the most diverse directions. The almost unlimited production of cheap water power from Niagara Falls fulfils the main requirement of profitable electrochemical manufacture—cheap electricity. The visiting and inspection of the different works established here should be most interesting, particularly to a society which is expressly devoted to the cultivation of the very subject of electrochemistry. In the past the majority of these plants have been closed to visitors, whether individuals or scientific societies, but it was confidently expected that an exception would be made on this occasion, and all the electrochemical plants at Niagara Falls thrown open to the society. This expectation was disappointed, however, the managers of the plants which had hitherto followed the policy of secretiveness decided that "there was no reason to diverge from their rule in the present case."

Nevertheless, the interest of the engineer, as against the chemist, was fairly well satisfied by the visits to those plants that opened their doors to the society. These were, the Niagara Power Co., the Hydraulic Power & Mfg. Co., the International Acheson Graphite Co., the Carborundum Co., the Atmospheric Products Co., the Natural Food Co., and the Electrical Lead Reduction Co. The Niagara Power Co. operates what is known as the "upper power plant," the power house of which straddles the famous Niagara wheelpit and develops 50,000 HP. of alternating current by ten great power units. As our readers know, this plant is being enlarged by the construction of what is virtually a duplicate of the old plant; the new wheelpit and power house are located alongside the headrace, directly opposite the old plant. This new power house, which is now quite near completion, could not be visited. The Hydraulic Power & Mfg. Co., known as the "lower power

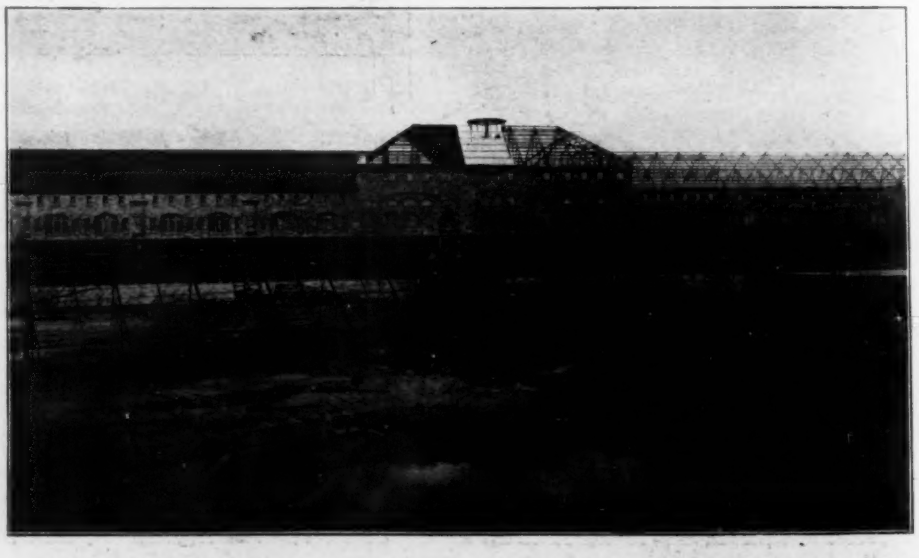


FIG. 7. VIEW OF FOREBAY AND POWER HOUSE, WITH RACK TRESTLE AND SPILLWAY CHUTE IN FOREGROUND.

plant," are located by the side of the Niagara gorge. The power house stands on the bank at the foot of the cliff, while three great penstocks, two of them 11 ft. in diameter, drop vertically over the edge of the cliff to the power house, bringing the water from a headrace leading from the upper reach of the Niagara River. This, as well as the upper power plant, are already well known to our readers. The same may be said of the works of the International Acheson Graphite

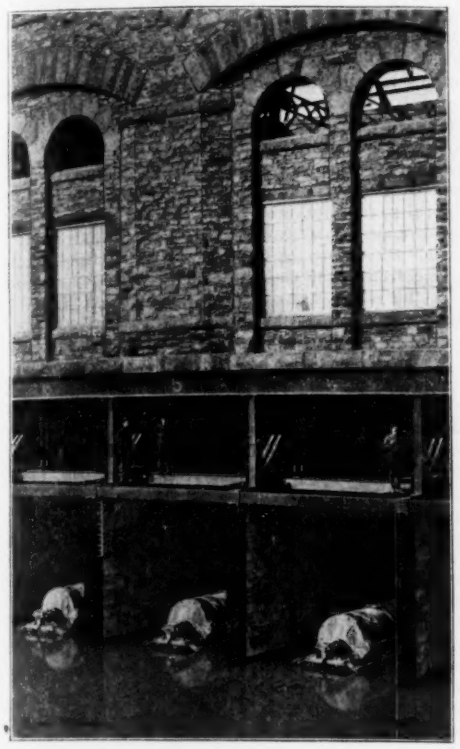


Fig. 8. Section of Power House on Forebay Side, Showing Turbines in Place.

Co., which make graphite from amorphous carbon, and the Carborundum Co., where the remarkable abrasive carborundum is produced. Both these plants use almost identical constructions of electric furnaces, each furnace looking like a rough pile of cinders and loosely-piled brick. Yet into such a pile is fed 1,000 HP of electricity continuously during 14 to 24 hours for a single heat—one of the most striking of the wonders to which electrochemistry has introduced us.

The Electrical Lead Reduction Co., whose plant is hardly yet in regular operation, make metallic lead from the natural sulphide, galena, by reduction at the cathode of an electrolytic cell. The method has recently been developed into a continuous process which enables a great saving in labor and in output to be attained. In the complete process the gaseous byproducts of the electrolysis will be manufactured into sulphuric acid, which will be obtained at an unusual degree of purity. The inventor of the process, Mr. P. G. Salom, of Philadelphia, a member of the society, claims that when this complete process is worked and the sulphuric acid sold at present market prices, the lead will be produced for nothing.

The Atmospheric Products Co., whose plant is as yet in an experimental stage, will make nitric acid or nitrates from the air, utilizing the fact that nitric oxide is produced by an electric spark in air. The present arrangement consists of a closed chamber in which a vertical shaft with metal fingers rotates so that the fingers make momentary contact with a series of stationary fingers attached to the case. There is a 10,000-volt potential difference between the sets of fingers, and each break of contact results in a spark or arc which is damped and extinguished by appropriate devices. The sparks cause the nitrogen and oxygen of the surrounding air to combine and form nitric oxide. A blast of air led through the chamber carries off this gas and leads it into solutions of caustic alkali. In this way the nitrate of the alkali metal, or saltpeter, is produced. A great future has been predicted for this process; it must be remembered that our nitrates today are mined from limited natural deposits, and that the formation of nitrogenous substances is an important feature in agricultural plant life.

The second session of the convention was held in the auditorium of the Natural Food Co., and the factory itself was later inspected by most of the members of the society. This is not an electrochemical plant, but an establishment for the manufacture of a prepared food of whole wheat. It is a most interesting plant, both because of the high organization of the process of manufacture, and because of the extensive provisions for the care of the employees of the company. The manufacturing process is briefly as follows: The wheat passes through separators, automatic scales and washers into cylindrical cages of wire cloth, which are then immersed in boiling-vats for 35 minutes. From here the grain passes to the floor below into a large drying room, where it is dried for 24 hours in shallow wooden pans. The grain is then dumped down chutes, which, on the floor below, feed the "shredding" machines, in which a large number of pairs of fluted rolls, placed in tandem, squeeze and roll out the grains into threads. These threads fall upon a longitudinal traveling belt under the rolls, forming a thick layer. The layer of "shredded wheat" passes into a biscuit molding machine, which has a great number of molds mounted in opposite halves on two traveling belts. This machine discharges the molded biscuits into large pans, which are then placed in an oven and baked a definite length of time. After being taken out the pans travel through a drier, which removes the remaining moisture from the inside of the biscuit. From another traveling belt the biscuits are then placed in cardboard boxes by girls, this being practically the only time the material is touched by human hands from the time the wheat enters the separators. Another machine closes and seals the boxes, which are now packed in cases ready for shipment.

Before considering the technical proceedings of the convention, it may be mentioned that a banquet and ball were held on Wednesday evening, and on Tuesday evening a trolley trip over the Niagara Gorge trolley line took place. On this trip a car fitted with a powerful searchlight accompanied the party. The route was from Niagara Falls to Kingston and return, some six or seven

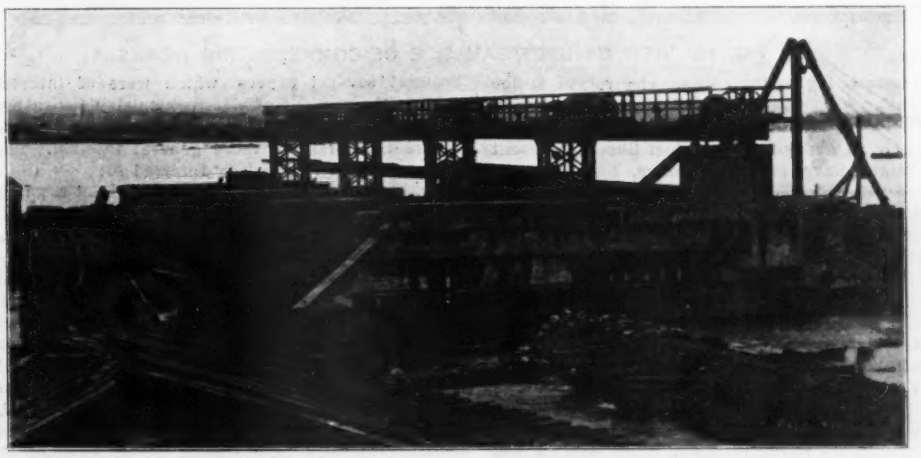


FIG. 9. GENERAL VIEW OF COMPENSATING WORKS IN ST. MARY'S RIVER.

(Four Stoney Sluices at Head of Rapids, With Steel Gates 48 ft. Wide and 15 ft. High, Operating Between Masonry Piers and Abutments.)

miles each way, passing along the entire length of the Niagara gorge, with its magnificent rapids, to the head of navigation on Lake Ontario. This trip was one of the most enjoyable features of the convention.

Technical Proceedings.

NOTE ON TESTING CARBON ELECTRODES.—By F. A. J. Fitzgerald, Niagara Falls, N. Y.

The author describes methods for two important tests on carbon electrodes. These latter are found to differ widely in durability in different cases, some electrodes having a long life, while others disintegrate rapidly and soon fail. It is desirable that there shall be simple commercial tests by which the quality of an electrode may be judged, in the interest of the maker as well as the user. The density of the material of the electrode and its porosity are important factors in its durability; the greater the density of the material, and the less its porosity, the longer will be its life in service.

Methods are described for finding the real and the apparent density, from which the porosity may be calculated. A second very important factor in the life of carbon electrodes is their composition. In general, amorphous carbon suffers rapid oxidation and disintegration, while graphite is very durable. In graphite electrodes, however, any even small quantities of amorphous carbon are detrimental in proportion to their amount. To give rapid determination of the amount of this undesirable material, the author has devised a special method, depending upon oxidation of the material by a solution of chlorate of potash in nitric acid, and the brown coloration produced by the oxidation of amorphous carbon. The method is in use in the laboratory of the Acheson Graphite Co.

DISCUSSION.—Prof. W. A. Hart suggested the use of persulphates as an oxidizing agent, and called attention to their large use in the determination of manganese in steel. Prof. R. S. Hutton remarked that graphites obtained from metal solutions differed, depending upon the metal used, and asked about the bearing of this fact on the author's method of determining the amorphous carbon. In reply, Mr. Fitzgerald acknowledged the suggestion of Prof. Hart as new to him, and possibly useful in connection with the method of test described. Answering Prof. Hutton, he stated that he was aware that different graphites are obtained from different metal solutions; he had, in fact, found manifestations of these differences in using his method, but they did not affect the determination of the amorphous carbon.

THE EFFICIENCY OF ELECTRIC FURNACE OPERATIONS.—By Prof. J. W. Richards,* Bethlehem, Pa.

The author began by emphasizing strongly the great difference in efficiency between small and large electric furnace operations. This difference results from the much greater rate of increase of output and power consumption, hence of heat liberation, than of radiating surface. In general, this matter of size is by far the most important in fixing the efficiency, and the latter may thus vary from say 10% in small operations to possibly 90% in very large ones. He then took up a number of specific cases of commercial electric furnace work, for which he had calculated the efficiency. He defined efficiency as used here to be the ratio of the energy required to heat the material up to the proper point, plus the energy required for the chemical changes, to the total energy expended.

*Professor of Mineralogy and Metallurgy, Lehigh University, Bethlehem, Pa.

The following is a summary of the results of the author's calculations:

In the electrolysis of salt for the production of metallic sodium (Acker process), 7% of the total energy was required to bring the materials to fusion and the working temperature, 54% was required for the electrolytic separation, and 39% was radiated; the efficiency was, therefore, 61%.

For producing barium oxide and sulphide from the sulphate, an efficiency of 60% was calculated.

In the manufacture of artificial corundum (Norton Emery Wheel Co.) by heating alumina (without any chemical reaction), the efficiency was 74%.

In making calcium carbide the heating consumed 15%, the chemical reaction 47%; efficiency therefore 62%.

In graphitizing anthracite coal (Acheson process), there is probably a gain of heat by chemical reaction, estimated at 10% of the energy input. Out of the 110% of the electrical energy, thus available, 75% are utilized. In graphitizing miscellaneous articles of amorphous carbon the heating of the articles consumed 40%, heating the packing material 30%. Since this latter is necessary to the operation the efficiency may be considered to be 70%.

In refining alumina the efficiency is nearly 60%.

In making carborundum the efficiency is 57 to 62%, with about 53% absorbed in the chemical reaction.

The author called attention to the quite uniform values of these calculated efficiencies. He also expressed the opinion that in the case of simple melting by the electric furnace the efficiencies were usually higher than where electrolytic action was involved.

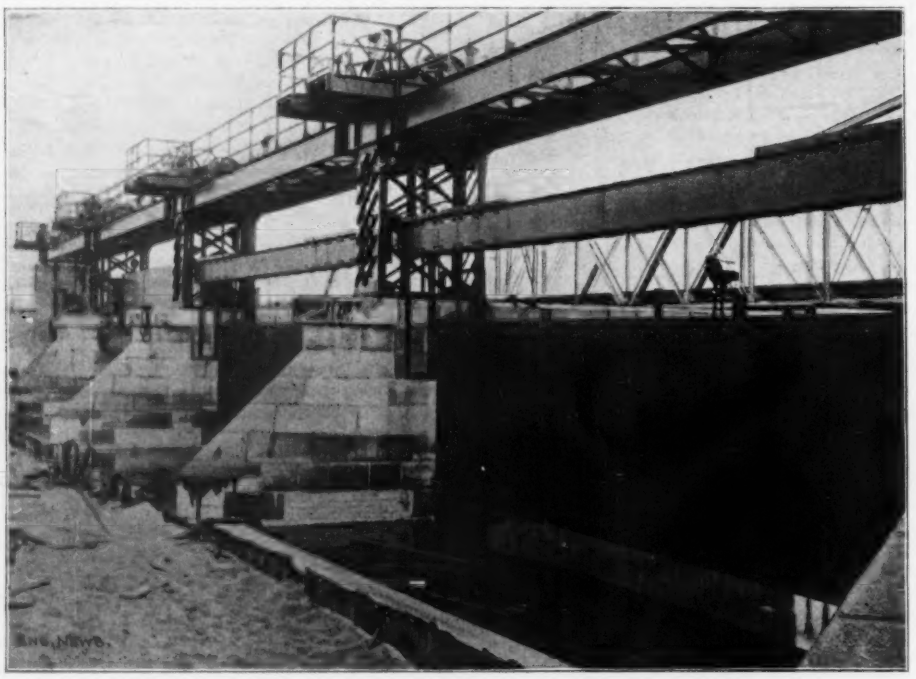


FIG. 10. VIEW OF UPSTREAM SIDE OF COMPENSATING WORKS.

DISCUSSION.—Mr. Carl Hering remarked that efficiency as applied to a subject like the present one might have many meanings, but that the author had specified the meaning which he used. He stated that a form of efficiency-statement which would often be found most practical was in terms of output per KW.-hour. He also drew attention to a quantity, difficult to calculate, which figured in certain electric furnace operations—the leakage of current through the (firebrick) lining when this became very hot and thus acquired a measurable conductivity. Prof. W. H. Hart brought out the commercial importance of the subject of the paper in those cases where no cheap water power was available for the work, as, for instance, in the manufacture of nitric acid, which cannot be shipped great distances, at a distance from a water power. Prof. F. Haber asked on what basis of output the author's figures for calcium carbide were based. In reply to this question, Prof. Richards stated that the figure of 4 tons a day, using 1,000 HP., had been employed. Answering Mr. Hering, he stated that the leakage through the furnace lining was generally negligible; he had calculated it for one case and found it to be only 4% of the total energy.

A paper by Mr. A. T. Weightman, of Niagara Falls, N. Y., on "Cathodic Reduction," referred to the Salom process of reducing lead from native galena. It treated of a number of anomalous phenomena encountered, in relation to the action at mixed cathodes. The matter brought out was entirely in the realm of pure electrochemistry, though important in its bearing on the commercial practicability of the electrical reduction of lead. The discussion, in which Mr. C. J. Reed, Mr. C. Hering, Prof. F. Haber, Prof. R. S. Hutton and others took part, was of the same nature. A paper by Prof. L. Kahlenberg, of Madison, Wis., on "Differences of Potential Between Metallic Cadmium and Solutions of Cadmium Iodide in Various Solvents," was also of purely physico-chemical interest. It was a communication detailing the results of a number of experiments recently made. Equivalent solutions of cadmium iodide in a number of different nitryls and amines were put in circuit with an Ostwald standard electrode, and the total pressure measured. It was found that the net potential difference of the cadmium cell varied greatly, varying between from 4 to 50 millivolts for the nitryl solutions, and 350 to 470 millivolts for the amine solutions, as against 182 for an aqueous solution. There was no discussion on this paper.

The second session, on Tuesday morning, brought several papers which were of interest only to the student of electrochemistry (or rather more broadly, physical chemistry), and some others that were of more general interest. The former will be only briefly referred to:

Mr. Carl Hering, of Philadelphia, read a paper entitled, "An Apparent Electrochemical Paradox." It described an experiment in which water was electrolyzed at various pressures; the voltage required was found to decrease, contrary to what was expected, while the yield of gases decreased. An explanation was offered involving a direct transfer of portions of the products of electrolysis between the electrodes, and the recombination of these portions. The discussion of the paper brought out confirmation of this explanation from several, and a number of other observations on the same question. Messrs. H. Rodman, W. M. Johnson, C. J. Reed and Profs. H. S. Carhart, R. S. Hutton, L. Kahlenberg, F. Haber, W. D. Bancroft and C. F. Burgess took part in the discussion. A paper read by Mr. E. A. Byrnes, of Washington, D. C., on "Galvanic Action with Fused Electrolytes," recorded a number of observations on the potential of cells using fused sodium hydroxide, with electrodes of carbon, iron, etc., and with various depolarizers. In "The Nickel Concentration Cell," Prof. H. S. Carhart, of Ann Arbor, Mich., presented results of his most recent work with this peculiar cell. Profs. W. D. Bancroft and F. Haber, Messrs. C. Hering, A. T. Weightman, C. J. Reed and others discussed the paper. There appeared to be considerable difference of opinion, or lack of opinion, as to whether this cell was thermic or whether chemical changes took place, as to what constitutes a pure galvanic cell, and as to the nature of thermic action in cells. The other papers of the session are briefly abstracted in the following:

DEVELOPMENTS IN ELECTROMETALLURGY OF IRON AND STEEL.—By M. Ruthenburg, Philadelphia, Pa.

This paper, which was of a very optimistic tone in regard to electric smelting of iron, first reviewed the commercial possibilities of the application of electricity to this work on accepted lines, and then described a method devised by the author which yielded more complete results with simpler means. According to present knowledge, electricity may be used in blast-furnace work for concentrating ores containing magnetite. This mineral, which is attracted by the magnet, is separated by subjecting the crushed and finely pulverized ore to the action of electromagnets. The mineral pyrrhotite, a sulphide of iron, is also subject to magnetic attraction, but less so than magnetite. By careful adjustment of the strength of the electromagnet this mineral may be separated from the magnetite. One of the principal drawbacks to magnetic concentration of iron ores is the fact that the resulting material is in the form of a very fine powder, which cannot in that form be reduced in the blast furnace. To change this powder into a form suitable for use in the blast furnace, it is usual to make it into briquettes. Various binders are employed to give the briquettes the necessary consistency; lime, coal-tar, clay, etc., have been suggested, but none is satisfactory. The author now suggests another method of producing a suitable ore from the fine concentrate. He would pass the powder through an electric arc in such a fashion as to partly bake or fuse the particles together into coherent, solid lumps; these latter are in proper form for smelting in the blast furnace. By modifying this method a little, adding a reducing material to the concentrate powder in proper proportion, a direct reduction, either partial or complete, may be produced. A very pure iron would thus be made, since the usual sources of sulphur, phosphorus and other impurities are absent. The product of the reduction could be melted in the open-hearth furnace and blown to steel, giving a pure material suitable for the finest uses. The author then referred to ferruginous beach sands, found in many places, as a source of iron ore which could be economically worked by the process he described.

DISCUSSION.—Prof. W. H. Hart mentioned an interesting new electric concentrating process which he had seen in operation in a small way during the past summer in Denver, Colo. This process, after patents by Prof. L. I. Blake, of the University of Kansas, was electric rather than magnetic; it consisted in charging the finely powdered ore by means of a Holtz machine and thus separating the ore by repulsion. Prof. Hart thought that the author was entirely too sanguine in regard to the possibilities of electric iron smelting. He himself thought the blast furnace one of the most economical metallurgical processes in existence. Mr. N. S. Keith suggested roasting the ore to convert pyrrhotite to magnetite before the magnetic separation. He remarked upon the multiplication of processes preliminary to reduction which is involved in the methods described by the author, a multiplication which would in most cases be absolutely prohibited by the expense involved. He referred to Mr. T. A. Edison's electromagnetic concentration process, which experience showed could not be economically worked. Mr. C. J. Reed, in this connection, referred to the many special conditions encountered by Edison which increased the difficulties and the cost of his work, and claimed that because of these the process could not be condemned because of Edison's failure with it. Mr. P. G. Salom expressed his belief in a future for electric smelting of iron, but thought that at present, on account of the great quantities of high-grade ore existing there was no economy in concentrating low-grade ores. Prof. J. W. Richards gave the result of a rough calculation he had made from the data of the author's paper: the figure given in the paper for power consumption in electrically fritting the magnetite

into lumps, as proposed by the author, was a low estimate of power required, since, according to the speaker's calculation, it would involve an efficiency of 83% in the process. Still, taking his estimate for power, and assuming the cost of electric power to be $20 per HP.-year, as at Niagara, the cost of this fritting process alone would be $2.67 per ton of ore treated. This figure speaks strongly enough for the commercial impracticability of the process at present.

THE FUSION OF QUARTZ IN THE ELECTRIC FURNACE.—By Mr. R. S. Hutton,* Manchester, England.

Quartz is very difficultly fusible; only in the hottest part of the oxy-hydrogen blowpipe flame does it become fluid or nearly so. When thus melted, it forms a transparent, glass-like amorphous substance known as vitrified quartz. This is superior to glass in every way. It is very strong, has a low coefficient of expansion and desirable optical properties, and is very much less affected by chemicals than is glass. It would, therefore, be of great advantage to be able to construct chemical apparatus of vitrified quartz. Mr. Hutton has applied the electric furnace to this work with some success. Some excellent work has been done in Germany in constructing apparatus from quartz by means of the oxy-hydrogen blowpipe; the method is extremely laborious, separate little rods or threads being drawn from the quartz and these then built up to form tubes, etc., and fused together. Quartz melts in the heat of the electric arc, but the strong reducing power of the hot carbon, which causes the silica to reduce and combine with the carbon, etc., has generally foiled all attempts at utilizing this method to construct tubes and other apparatus of quartz. Mr. Hutton finds that if care be taken to supply a strong oxidizing atmosphere this trouble is avoided and clear vitrified quartz is obtained. His method of employing the arc consists in letting it play over a half mold of semi-cylindrical form, made of graphite, with a graphite rod placed to form a core for the desired quartz tube. Crushed quartz is placed in the mold around the rod and a cover of limestone or graphite used to confine the arc over the mass; graphite electrodes placed lengthwise over the mold furnish the arc. A direct current of 300 to 500 amperes, at 50 volts pressure, was used. He also succeeded in melting some quartz in a small crucible, and here found that he actually got fluid-fused quartz, instead of only a pasty, semi-fluid mass. Another method of forming tubes which he tried was to heat a graphite rod by an electric current in a mass of crushed quartz; the particles around the rod partly baked together to form a rough tube which could in a second operation be fused completely in the heat of an arc.

DISCUSSION.—The discussion on the paper showed that a number of others had worked on the problem of electrically fusing quartz, both in this country and abroad. Mr. C. A. Doremus spoke of some quartz Geissler tubes which he saw Prof. Crookes have some years ago; he did not know who made them. Prof. W. D. Bancroft stated that articles of apparatus have actually been cast from fused quartz in this country. Prof. W. R. Whitney stated that he had made crucibles of quartz, but had never succeeded in getting rid of the opalescence caused by many minute bubbles of air. Mr. Hutton said that he had himself never obtained a clear, transparent material, the air bubbles being so numerous and so small as to make it almost impossible to get rid of them.

On Wednesday two sessions, morning and afternoon, were held, due to omitting a picnic planned to be held at Queen Victoria Park. These sessions were each appreciably shorter than those preceding, as was also the session of Thursday morning. Moreover, the subjects presented for discussion during these last two days of the meeting were of a miscellaneous character, being grouped by convenience; the three sessions may, therefore, suitably be considered together.

Prof. H. T. Barnes, of Montreal, Que., read a paper on "Theory and Practice of Continuous-Flow Calorimetry," which described an instrument for determining specific heats of liquids. The errors of the apparatus were discussed and some results obtained with it were presented. Profs. L. Kahlenberg, H. S. Carhart and W. R. Whitney, and Messrs. R. S. Hutton, H. N. Potter and C. J. Reed spoke in discussion. A paper was presented on "The Electrolytic Dissolution of Soluble Metallic Anodes," by Mr. W. M. Johnson, of New Brighton, New York city. Prof. F. Haber, of Karlsruhe, Germany, in a paper on "The Phenomenon of the Formation of Metallic Dust from Cathodes in Electrolysis," described a phenomenon which he and others had observed and investigated. Lead, tin, bismuth, etc., in alkaline hydroxides above a certain strength give clouds of metallic dust at the cathode. This was explained as being due to the formation of an alloy of the cathode metal with sodium or potassium metal from the solution, and the immediate reoxidation of this alloy. The discussion by Profs. L. Kahlenberg, W. D. Bancroft, H. S. Carhart, J. W. Richards, and Messrs. N. S. Keith, C. J. Reed and others, showed a general acceptance of the author's explanation of the phenomenon. The case where hydrogen acts similarly to the alkali metal, especially with platinum, was cited. It was pointed out that the phenomenon explained by Prof. Haber had an important bearing on commercial electrolytic work, since it explained why a given reduction is often accomplished with a cathode of one metal, where another metal has no action.

Mr. Arvid Reuterdahl, of Providence, R. I., discussed "The Electronic Hypothesis and Its Applications." He began by pointing out a few weak points in the recently-constructed theory of "electrons." From this point he proceeded, by exceedingly cloudy excursions of reasoning, to a condemnation of the law of gravitation; he finally finds the saving solution of the difficulties besetting the "electron" theory in substituting for the law of gravitation the "law of electric attraction and repulsion." There appeared to be little or no disposition to discuss the paper; before the next subject was called up, however, Prof. H. S. Carhart claimed the floor to enter serious protest against the ideas and reasoning of the paper. In regard to the author's idea of the mechanics of the atom and the molecule he referred him for correction to Clausius' treatment of the potential function. The conclusions of the author, resting on such a basis as this, Prof. Carhart directly characterized as absurd. Mr. Reuterdahl made a brief reply, insisting on his position against Prof. Carhart, after which the chairman declared the discussion closed.

A paper by Prof. J. W. Langley, of Cleveland, O., on "Electrochemical Polarization," read by Mr. H. N. Potter, started a discussion as to what polarization really is, or rather what phenomena should be given the name polarization. Prof. Langley, in his paper, defined it as the counter e. m. f. of the electrolytic cell in question, measured during the charging process, or at an infinitesimal time interval later. Prof. J. W. Richards preferred to call this value the counter e. m. f. of the cell; he would define polarization to be the increase in ohmic resistance of the cell during charging, due generally to films of gaseous products of electrolysis. Messrs. A. H. Cowles, C. J. Reed and H. N. Potter also discussed the paper.

Mr. C. J. Reed, of Philadelphia, Pa., presented a paper on "Some Phenomena of Electrolytic Conduction," which was read in the author's absence by Mr. C. Hering. The author described an experiment on an electrolytic cell with two liquids separated by a diaphragm, in which, on passage of a current, the liquid rose in one compartment while theoretically it should have risen in the other. A rather brisk discussion followed the reading of the paper, Prof. J. W. Richards, Messrs. C. Hering, A. H. Cowles, H. N. Potter and others taking part. The discussion dealt to some extent with the dissociation theory, and was the only occasion during the convention when this subject was touched upon; however, it was brought out that the results obtained by Mr. Reed were quite probably due to osmotic effects modified by current flow, a phenomenon often observed. The papers of more general interest presented during the sessions of Wednesday and Thursday are the following:

STORAGE BATTERY INVENTION.—By Mr. H. Rodman, Philadelphia, Pa.

The author considers the range of possible combinations forming reversible cells. Various objections against different cells, cited in the paper, reduce the list of cells having practical, commercial value to two: (1) the well-known lead storage cell, using lead peroxide and spongy lead as electrodes, in an acid electrolyte; and (2) the nickel peroxide cell, in which the active electrode consisted of nickel peroxide in an alkaline electrolyte, the other electrode being iron, carbon or some similar substance. The author next examined each of these types for advantages and disadvantages. He finds that the nickel cell readily permits of satisfactory mechanical construction of the electrodes, in some contrast with the lead cell in this respect. The alkali of the former is apt to be far more troublesome in various ways than the acid electrolyte of the lead cell. The nickel cell greatly leads the other in length of life, but this favorable ratio is liable to be affected by excessive local action in the nickel cell. In the matters of weight and cost, the advantage lies on opposite sides; the nickel cell is the lighter, but generally only slightly so, while the lead cell is considerably the cheaper. Storage batteries at present find their largest application in central station work, 75% of the total output being for this use. For central station and all similar work the lead battery will maintain its position; its direct advantages over the nickel cell make it preferable here. On the other hand, the nickel peroxide cell, because of its lesser weight, bids fair to create a large field of use for itself in automobile work.

A UNIT OF QUANTITY OF ELECTRICITY FOR USE IN ELECTROCHEMICAL CALCULATIONS.—By Mr. A. H. Cowles, of Lockport, N. Y.

The author made the accidental discovery that a current of 500 amperes acting for one day will set free within two per cent. of one pound of hydrogen. This relation struck the author as being well suited for the creation of a new unit of electric quantity that should be better adapted to electrochemical work than the coulomb. In searching farther into the matter, he found that this same current will set free exactly 5 cubic meters of hydrogen in one day, or 100 amperes will set free 1 cu. m. in one day. The author speaks of this relation as an exact one, and assumes it to be a definite qualitative scientific phenomenon. With this as an introduction, the remainder of the quite extended paper divides itself into two parts: in the one he suggests that this relation be made the basis of a new unit of quantity; this unit should be a quantity of electricity equivalent to 100 amperes of current flowing for one day, or 2,400 ampere-hours. He further discusses the applicability and value of this unit in various directions, and argues for it a great convenience of calculation, especially in electrochemical work. The second part of the paper is strikingly original in thought. Mr. Cowles goes deliberately about seeking a physical reason for the observed fact that 100 amperes will in one day liberate just 1 cu. m. of hydrogen. It will be evident that such a reason must be a highly complex structure; Mr. Cowles has collected some of the material from which this structure is to be put together, thus: The day is a natural unit, since it is the time of the earth's rotation, and it involves as a main factor the mass and size of the earth. But the length of the meter is one ten-millionth of the earth's quadrant, and one cubic centimeter of pure water is attracted to the earth by the force of one gram weight. Now, from the centimeter, the gram, the second and the factor ten, we derive, successively, the dyne, the unit pole, the absolute unit of current, and the ampere. Mr. Cowles eliminates the second of time from this sequence by another ingenious and remarkable coincidence. We thus have 100 amperes, derived from the gram and the meter, as just brought out; the day, or the physically determined period of rotation of the earth, linked closely with the gram and the meter, and hence with the ampere; the cubic meter of hydrogen, that most mysterious of elements, linked with the two other items by its dimension, the meter. Here Mr. Cowles stops; he confesses that he is unable

*Lecturer on Electrochemistry, Owens College, Manchester, England.

to evaluate these complex relationships, or to give an answer to the why of the fact that is noted at the commencement of the paper.

DISCUSSION.—Remarks on the paper were made by Profs. J. W. Richards and W. D. Bancroft and Messrs. C. J. Reed, Carl Hering and N. S. Keith. Mr. Hering expressed entire disbelief in any such complex causal relation as Mr. Cowles had tried to show. Mr. Reed seconded this opinion. Prof. Richards went farther and condemned the matter as idle speculation. Mr. Keith took occasion to express his profound gratification at here for the first time finding a relationship between the much-abused pound and the meter.

SOME ADVANCES IN CLOSED AND CONTINUOUS WORKING IN THE ELECTRIC FURNACE.—By Mr. E. R. Taylor, Penn Yan, N. Y.

The closed continuous-working electric furnace is probably the most important and interesting type of electric furnace, since it is the one on which electrical engineers must rely to carry the electric furnace into broader fields of industry. Any improved designs that are the outgrowth of practical experience are, therefore, of interest. Mr. Taylor shows his latest design of electric furnace of the type named; this particular furnace is intended for the manufacture of carbon bisulphide by the combination of carbon and sulphur at high temperature. (Drawings of the furnace were shown at the meeting.) The furnace resembles an iron blast furnace in general form; the part corresponding to the bosh has the shape of a hemisphere, opening upward, from which the shaft, of a somewhat lesser diameter than the bosh or hearth, extends upward. The sidewalls are cored out to form passages, which are charged with sulphur; this melts and flows into the furnace from openings in the lower portion.

The electrode or current carrying core, of suitable material, finely granulated, lies diametrically across the hollow of the hearth. Openings in the sides, just above the holes through which the current contacts connect with the core, permit of regulating the furnace by introducing high or low resistance material. The product flows out through a tapping hole in the bottom of the hearth. A noteworthy statement was made in the course of the paper by its author, who is among the foremost practical workers with the continuous electric furnace. He stated that with less nerve on his part and less actual risk of failure than it required to build the furnaces he works at present, he could construct a continuous electric furnace that would dwarf the largest blast furnace in existence. Mr. Taylor's present furnaces are 16 ft. by 40 ft.; they are used for making carbon bisulphide.

PUMPS AND OTHER ACCESSORIES IN ELECTROLYTIC PLANTS.—By Mr. D. H. Browne, of Cleveland, O.

The question of pumping liquids, or more broadly, that of handling and treating liquids, is a simple one in general, but becomes a very difficult one in the case of electrolytic work. Mr. Browne's recital of the troubles arising from this source in a large electrolytic copper refinery is of interest on this account, as well as because the problem is rather new. The liquid to be handled in Mr. Browne's case was a mixture of chlorides of copper and other metals. These salts alone in solution would be bad enough, but a little free acid, free chlorine, sand, wood, chips, etc., the whole liquid being hot, make the matter worse. The pumping is the largest question. The first case of trouble resulted from trying to force the liquid through a filter press with a diaphragm pump; it was afterward found that a pressure of 100 lbs. was about right for this work. In another case, for low pressure, a stoneware pump was tried; the pump had wooden piston and rod and a rubber sheet over the piston for packing. After some changes this was found fairly satisfactory. In the next case a rubber pump, steam-driven, was tried. It worked all right cold, but when it was tried to pump hot solution the rubber cylinder began to swell. The finally adopted method for pressure work was to use a stoneware forcepump, molding a solid concrete block around it in order to make it easier to handle, and connect up, etc., as well as to guard against breakage. In connection with pumping, the delivery mains gave much trouble, and a similar method has been adopted here: the use of sewer pipe with concrete molded solid around them. Another apparatus which caused much vexation was a heater for heating and concentrating the solution. A stoneware pot set in an iron heating vessel, as at first tried, finally developed into a concrete evaporating pan and from this into a continuous evaporator, where an oil-heated current of air is directed upon the solution flowing in a thin sheet over a concrete surface.

DISCUSSION.—Mr. C. Hering and Mr. N. S. Keith advocated the air-lift system for handling liquids such as described. It was said to be of almost universal applicability, and to be of particular value when the aeration and resulting oxidation of the solution is advantageous. Mr. W. M. Johnson mentioned the steam injector as being very serviceable when the slight additional dilution of the liquid was of no moment.

THE NATURAL GAS PRODUCTION of the United States in 1901, says the U. S. Geological Survey, was equivalent to 8,458,600 tons of coal, at 20,000 cu. ft. of gas equal to one ton of coal. The value of this gas production was $27,067,500, an increase in value of 14% over that of 1900. At the close of 1901 there were 10,297 wells producing natural gas; and in 1901, 2,088 producing wells were drilled. Nearly 800 miles of pipe were laid in the year, making a total of 21,848 miles of natural gas mains in use, varying from 2 to 36 ins. diameter. As a source of power natural gas stands at the head of the list for economy among fuels, both as to expense of installation and expense of operation. In the gas-belt, it has been lately extensively applied in creating the power by which the natural gas itself is compressed, when the original pressure has failed and the pipes are insufficient to deliver the necessary quantity of gas at the well pressure. A number of these compressors work close to 1,000 HP., with an economy that enables 8 to 10 cu. ft. of natural gas to develop one horse-power for one hour; this is a saving of 40 to 50% over high-duty steam engines. In manufacturing establishments 1,545 report the use of natural gas; these include 102 iron and steel works and 219 glass works.

NOTES FROM THE ENGINEERING SCHOOLS.

RENSSELAER POLYTECHNIC INSTITUTE.—A new laboratory is being erected for the chemical and bacterial examination of water. The intention is to make the equipment as perfect as possible. The Institute aims to devote special attention to the examination of water and all questions concerning water supply. Prof. William P. Mason is Professor of Chemistry at the Institute.

HANDLING FUEL OIL AT RAILWAY TERMINALS.

Oil fuel for locomotives is now being used quite extensively on lines in California and Texas, and an important matter which the motive power officers now have to consider is the best means of handling the oil at terminals; that is to say, the means of delivering it from the tank cars to the storage tanks, and from thence to the tender tanks. This subject was made a matter of discussion at the July meeting of the Pacific Coast Railway Club, at San Francisco. All the information related to methods employed at different points on the Southern Pacific Ry., and from this information we have compiled the following particulars.

At Bakersfield, Cal., the tank cars are unloaded by means of air pressure, but this is a slow process, as the pressure is limited to 15 lbs., and there is considerable trouble from the cars not being air-tight, besides which the heavy oil has to be heated in cold weather. It takes from 30 to 35 minutes to unload a car under the most favorable conditions. The oil is led to a two-compartment storage tank, and is fed direct to the tenders by means of air pressure from one or other of the compartments. It is considered by some, however, that the tender can be filled much more rapidly by oil flowing by gravity from an elevated tank than by forcing it under air pressure from a surface or underground tank. Where this method is adopted, the oil may be forced by air pressure from the storage tank to the elevated tank, and then drawn from the latter as required.

At Los Angeles, Cal., about 50,000 barrels of oil are delivered to the engines every month, this being a larger amount than that handled at any other point. The tank cars are run up an incline from the freight yards to a track on the hill side behind the storage tanks, and the oil is discharged by gravity into a trench or conduit between the tracks, the elevation being such as to allow the oil to flow by gravity from the conduit to the storage tanks. This avoids the loss of time involved in making pipe connections to discharge each tank car. From the storage tanks the oil is piped by gravity to a two-compartment distributing tank near the roundhouse, each compartment being of about 3,000 gallons capacity, and the oil is forced from the distributing tank to the delivery stand-pipes by compressed air. The admission and discharge of both the air and oil in this operation are automatically governed by a float arrangement in one of the distributing tank compartments. From the time the oil is delivered in cars by the yard force on the unloading track the only expense attaching to handling the 50,000 barrels of oil used per month is the compensation that goes to one man, and he makes tests of all oil received, and also renders reports to the office from which the bills are paid.

At Oakland, Cal., the oil is discharged from the tank cars into a 12-in. pipe, to which eight or ten cars are connected simultaneously, and from this pipe the oil is pumped to the storage tank. About 25,000 gallons per hour are handled. The pipe should be laid between two tracks and be long enough to connect with 12 cars, 6 on each track. The oil is again pumped from the storage tank to the elevated tank, from which it flows to the tender by gravity, or it can be pumped direct from the storage tank to the tender.

At San Bernardino, Cal., where only about 1,000 barrels of oil are used per month, the rails of the oil car track are level with the top of the receiving tank, which is loaded by gravity, and from which the oil again flows by gravity through a 4-in. pipe to a pressure tank connected to a stand-pipe and spout. For charging the tender, connection is made between the tank and the air brake hose at either end of the engine, a check valve in the 4-in. pipe preventing the air from escaping to the storage tank. This arrangement would not be practicable at points where large quantities of oil have to be handled, while on the other hand it would not be economical to use the two-compartment tank at a point handling only 1,000 barrels of oil per month.

At Tucson, Ariz., compressed air is used in unloading the tank cars, but (as at Bakersfield) there is much waste of air due to the fact that the cars are not air-tight. It has been recommended that the oil be discharged into a receiving tank, and thence forced by air at 50 lbs. pressure to the storage tank, which arrangement is now successfully employed in forcing the oil from the storage to the high-pressure tank. On this division steam has to be used to heat and thin the oil at some points, where the temperature sometimes falls to 32° F. This is specially the case with the California oil, which is thicker and heavier than the Texas (Beaumont) oil.

For small stations where air pressure is not available, small pumps are recommended for emptying the tank cars. A mining company uses for this purpose a small rotary pump driven by a 3-HP. gasoline engine, but a force pump operated by steam is considered as preferable, and the steam could be used to heat the oil when necessary. In some cases, however, gas generated by heating the oil has caused trouble in the pumps. The cost of pumping is estimated broadly at 3 cts. per 1,000 gallons, and unloading by air pressure would cost about the same except where there was a surplus of air available. Either method is considered as being cheaper than building an elevated trestle from which to unload the cars by gravity, as the interest on cost of a trestle, and the repairs, would probably amount to more than the actual cost of unloading the oil by either pumping or compressed air. At one point, where as yet only four engines have to be supplied with oil, the tank cars are run up onto a coal trestle, and the tenders are filled by gravity by means of a hose from the tank car.

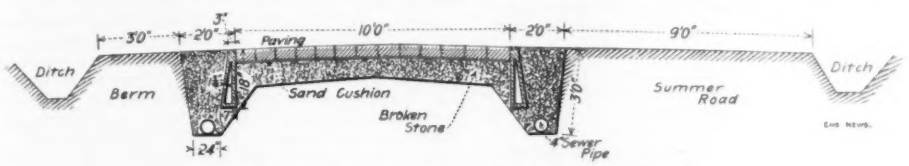
PAVING A COUNTRY ROAD WITH BRICK.*

By Sam. Huston, C. E.†

The first circumstance or condition entering into the problem was the location of the road it was proposed to improve along the bank of the Ohio River at such an elevation, or rather want of elevation, as to bring about the covering of the road on an average of about once a year with high water, carrying to its fullest capacity the fine sediment resulting from the disentegration of coal measure shales, and leaving thereon after subsidence a tenacious and retentive mud, absolutely destructive to the surface of a macadam road and thus requiring excessive expenditure for maintenance. The thorough occasional soaking of the roadbed attendant upon these high water stages, added another element to the problem of construction with permanency in view. In this I recognize the only element of uncertainty as to the success of the experiment.

The conditions favorable to the experiment were the location of the road with reference to the materials used in construction, that is past works producing what are, without any question, the best paving brick manufactured, the celebrated Ohio River paving brick, manufactured under conditions as to economy of production rarely equaled. For material for foundation the same element of accessibility of waste material from sewer pipe works made it possible to adopt that nearly indestructible waste for the construction of a foundation which we hope will neutralize the uncommon condition due to soakage referred to above.

The drawings‡ herewith are illustrative of the references in the description below, which are but explanatory of the selections quoted from the specifications under which the road was constructed. The selections given are only those referring to requirements peculiar to the form of improvement under consideration.



DETAILS OF BRICK PAVEMENT ON A COUNTRY ROAD.

UNDERDRAINS.

Four-inch sewer pipe drains, length of joints 2 ft., shall be laid to grade in the trenches at sides of paving as indicated on cross-section sheet, and will be practically continuous on each side of the pavement. All sewer pipes shall be of shouldered, hard-burned, glazed fireclay pipe of good quality. Fire cracks or slight deformations that do not affect strength or capacity will be allowable, but pipes otherwise defective must not be delivered along the road.

These 4-in. sewer pipes were placed in trenches under the curbing and 3 ft. below the finished grade of the road, not because the ground was more than ordinarily in need of drainage, it being mostly a sandy loam, but in order to effectively and promptly carry off the water under the paving upon the recession of the frequent floods referred to above.

The grade, spoken of above, throughout nearly the entire length of the road improved, was from 3 to 12 ins. per 100 ft. The 3-in. grade I considered undesirable, but funds were not available to secure a heavier grade, although we used the debouchure of several minor streams about 1,000 ft. apart, to secure without much extra expense the above minimum grades, and at the same time not bring the lowest points of the pavement below a certain uniform minimum, about 1 ft. above the level of what are considered dangerous floods. For a distance of about 1,600 ft. the pavement was laid over material 6 ft. or more in depth, consisting of the waste from fire clay brick kilns and sewer pipe works. This material gave good drainage and it was deemed unnecessary to use the 4-in. tile over such fills. Otherwise the double line of tile was continuous for the entire length of road.

FOUNDATION OF BROKEN VITRIFIED PIPE.

Foundation material shall consist of broken vitrified sewer pipe, which shall be broken to pass through a 2½-in. ring, with sufficient finer material to fill voids after rolling and prevent sand cushion from passing downward. Such material shall be placed in the trenches over the 4-in. pipe and around the same up to within 18 ins. of the surface of the sides of the completed pavement, and together with the subgrade, shall be thoroughly rammed, or rolled with a roller weighing or weighted to 8 tons. Said work being done when the sub-grade is in a moist condition, and care shall be used that the sewer pipes are not injured, crushed or displaced."

The material used was the waste of the works, consisting of rejected and unmerchantable sewer pipe, broken by hand with light sledges, mostly in the trenches and on the sub-grade. For finer material furnace cinder was used by consent of the Pike Commissioners, and if there is any weakness about the manner of construction, or carrying out the specifications, it arises from the use of too large an amount of cinder, and a want of proper incorporation of the same with the broken sewer pipe. The subgrade was rolled and any unforseen unevenness growing out of the nature of the material of the sub-grade, was made up with the foundation material.

VITRIFIED CLAY CURBING.

Curbing of quality and manufacture the same as Ohio River paving brick, 18 ins. high, 3 ins. wide on top and 7 ins. wide at the base, and not less than 2 ft. long, and of the form indicated on cross-section sheet, shall be placed and solidly bedded on the foundation as designated above, so as to stand true and even to grade and line.

This form and material of curb, so far as I know, is entirely new, was designed by the writer, and so far as the construction of the road is concerned, has proved its efficiency. In order to secure thorough burning, it was constructed hollow, with walls 1¾ ins. thick, is solid and substantial, having stood every test applied to it. Transverse fire cracks, where not too extensive, appeared of no detriment, but longitudinal cracks and inferior burning were the only sources of weakness, and the only defects calling for rejection. It was found that with proper care in handling during the process of manufacture, these defects were of infrequent occurrence. Where the whole curb is buried, as in the manner used in the road under consideration, they were found to be all that could be desired and demonstrated their serviceability. Curbing, I believe could be manufactured on the same plan adapted to gutter work, provided they were bridged in the part of the hollow against which came the pressure of the brick forming the gutter. The reasons for building the curb hollow were to secure uniform burning through the entire cross-section of the curb, to save material not necessary to strength, and reduce the weight, an important item in the cost of manufacture. The weight of the curb was 68 lbs. per lin. ft.

In the trenches partially filled as above and upon the sub-grade shall be placed layers of not more than 6 ins. in depth of above specified foundation material, each layer of which shall be rolled or rammed to the satisfaction of the engineer. The surface of such material when completed and rolled shall fill the trenches outside of curbing to the level indicated on the cross-section sheet as surface of completed road, and between the curbing to within 4½ ins. of the same, with smooth and even surface, with same curvature as completed pavement. Between the curbing and upon the foundation thus prepared and thoroughly compacted, a layer of clean dry sand shall be placed, and shaped to the form shown on cross-section sheet by a templet scraper, with a depth of ½-in. The above with the sand cushion shall be classed as foundation, and be bid and paid for by the cubic yard, measured when the road is complete.

CROWN OF PAVEMENT AND SLOPE OF SUMMER ROAD.

In the construction of the road 1 in. of sand was used instead of ½ in., and the surface of the brick, when the rolling of the same was completed, stood ½ in. above the curbing to allow that much settlement under travel. The crown of the road was determined by the form of the templet scraper referred to in the specifications. The scraper was made as follows, that is 10 ft. long, with the following measurements from a chord uniting the ends and at the following distances from the center: Center, 2 ins.; 1 ft. from center, 1⅞ ins.; 2 ft. from center, 1½ ins.; 3 ft., 1 in.; 4 ft., ½ in. Thus forming a curve for 4 ft., at the center, tangent to a slope of ½ in. per foot for the remaining 3 ft. at each side of the paved portion of the roadway. This latter slope was carried across the summer road and wing at each side of the paving. This brought the farther edge of the summer road 8 ins. below the center of paving as follows: Crown in paving, 2 ins.; side of paving above curb, ½ in.; fall of ½ in. per ft. of trench (curb and broken pipe) 2 ft., and summer road, 9 ft.; in all 11 ft. 5½ ins.

BRICK PAVEMENT.

Upon the sand cushion the brick paving shall be laid. The brick shall be of standard size of the best quality sound, tough, Ohio River fire clay paving brick, hard burned, of good shape, free from flaws, cracks or breaks. No bats should be used except at curbs, where half bricks shall be used to break joints. The engineer may subject samples, selected by himself, to any reasonable tests as to durability and fitness. Bricks shall be subject to any inspection designated by the engineer, both before and after laying, and all rejected brick shall be immediately removed from the work, and not returned to it, and the deficiency made good by the contractor.

The brick shall be laid on the sand cushion, on edge, at right angles to center line of paving, and be kept in even, straight lines; with all joints broken at least 3 ins., and in perfectly upright position, the brick to fit close on ends and sides. In making closure at curbs, care shall be taken in shaping and trimming not to check or fracture the bricks, which shall be broken or cut at right angles to their tops and sides, and the work shall be done by experienced men.

The brick shall then be covered with fine dry sand to be well broomed in, sufficient only to fill the interstices or joints. When laid as above, the brick shall be thoroughly rolled with a roller of five tons weight, and any portions of the pavement, that in the judgment of the engineer may require the same, shall be rammed to his satisfaction, either before or after rolling, a plank being used under rammers. After rolling, the surface of the paving shall be true and even to grade and cross section, must show no continuous lines, or unequal settlement, and the contractor shall remedy any such deficiencies. When complete as above the surface of paving shall be evenly covered with ½ in. of clean, dry sand.

In reference to the last quotation it is only necessary to add that the brick used, the "Ohio River fire clay paving brick," have proved themselves, according to my observation extending over more than 20 years, and in comparison with many other kinds of brick used in different cities and under various conditions, the most reliable and enduring pavers manufactured. I have seen them in quite a number of cities used on adjoining streets to many other kinds of pavers, and they have demonstrated their superiority, especially in the line of durability.

The sand used on the first paving laid was rather loamy, and would undoubtedly have proved detrimental, had no several weeks of extremely dry weather succeeded to its use. This dry season however counteracted any tendency injurious to the road, and clean sharp sand was used subsequently.

The following is a copy of the final estimate on the work:

Excavation	10,334 cu. yds.	@	$0.12	$1,240.08
Overhaul	47,490 " "	@	.01	474.90
Grubbing trees	18 each...	@	1.00	18.00
4-in. sewer pipe	8,012 lin. ft..	@	.06	480.72
Curbing	10,784 " "	@	.20	2,156.80
Foundation	3,413 cu. yds.	@	.22	750.86
Paving	6,243 sq. yds.	@	.52	3,246.36
Total				$8,367.72

The total length of paving, exclusive of bridges, was 5,479 ft.

The low price for excavation was obtainable because the contractor was able, before the work was let, to arrange with a manufacturing plant, located within 300 yds., to use their waste for the construction of the heaviest fill on the contract, which material was delivered in place without expense to the contractor. The price for overhaul, 1 ct., was for each 100 ft. or fraction thereof each yard was moved in excess of 100 ft.

*Slightly condensed from a paper read before the Ohio Society of Civil Engineers and Surveyors, Jan. 20, 1902.

†Steubenville, O.

‡Redrawn and combined in one sketch.—Ed.

REPORT ON WATER-WORKS RATES AND VALUATION AT SAN ANTONIO, TEX.

When difficulties arise between cities and water companies over water rates or other features of franchises, prolonged controversies generally result, all of which might be avoided by seeking and following competent and disinterested advice. One of the all-too-rare instances in which the latter course was adopted has recently been happily terminated at San Antonio, Tex., where the city and the water company employed Mr. Chester B. Davis,* M. Am. Soc. C. E., to aid them in formulating a new contract, including a schedule of water rates. The contract submitted by Mr. Davis was signed by both parties on June 13, 1902. The methods pursued in arriving at the value of the works, the rates to be charged, and a basis for future adjustments of rates, together with a clear and forcible exposition of the principles involved, are set forth in detail in a report by Mr. Davis, which might profitably be added to the library of any one having similar problems to solve. The report is also valuable as an engineering study of some of the needs of fair-sized water-works plants which are afflicted by the many ills due to an inordinate consumption and waste of water. And the document is of still further value as an exposition of the mutual relations between water companies and municipalities.

The present contract between the San Antonio Water-Works Co. and the city of San Antonio will expire on June 4, 1904. The city claims rights, under its charter, to regulate the rates of the company, and the two parties began negotiations, months ago, for a renewal of the contract. The company urged, in connection with discussions of the relation between rates and the value of plant, that extensive improvements, mostly in the nature of enlargements, were necessary.

Mr. Davis first shows the true relationship between a water company and a city, which may be summed up by saying that the company is a public servant, which has assumed and must perform certain duties, while the city and its inhabitants must pay the reasonable value of the services rendered, must not abuse the privileges offered, and must afford all necessary police protection.

The report shows the need of largely increasing the reservoir capacity and the number of fire hydrants, and of cutting off half or more of the water consumption and waste. The need of the

*10 Wall St., New York city.

latter will be apparent when it is stated that the average daily consumption is about 200 gallons per capita, the supply limited, and the capacity of the various parts of the works already reached or overtaxed.

The remedy for waste, and particularly the method of applying it, is perhaps the weakest part of the report. The primary means of waste prevention is house-to-house inspection, conducted by the city instead of the company, with meters on small consumers as a last resort. It is only fair to say that the value of meters in general is recognized and emphasized in the report, but Mr. Davis does not think it advisable to apply them to small consumers, except as a last resort, the need to be determined as already stated. It should also be added that the city inspection feature is not inserted in the contract.

The contract proposed and adopted provides for a payment of $24,000 a year for water for all public purposes,

including public parks, public buildings, sprinkling or flushing streets, flushing of sewers by tanks so arranged as not to empty more than twice in 24 hours; providing that dead ends of sewers may be flushed with hose; and including the present fire hydrants and the additional hydrants to be placed under this contract; excepting, however, water used for the purposes of creating power* and for ornamental fountains. . . .

There will also be included under public purposes water for water-closets ordered by the city council, on report of a sanitary inspector of the city to the effect that the occupant of a house "is not a water taker and is unable to pay for water."

The flat rates in the new contract are about the same as those in the old one. Only what may be termed the household rate will be quoted here. That is fixed at $8

for all kitchen and household uses, including one water closet, subject to voluntary meter service and rates by the consumer, or by the water-works company in case of undue waste of water on the part of the consumer, as provided herein.

The last three words relate to a clause authorizing the company to make inspections for waste and to install a meter if the waste is continued after due notice of the same.

For domestic meters the minimum charge is 66 cts. per month, or $7.92 per year, for 4,400 gallons used in one month, with 14 cts. per 1,000 gallons for all in excess of that amount. The volume stated is about 150 gallons a day for a family of four, and the minimum rate amounts to 15 cts. per 1,000 gallons.

For commercial meters the rate is 25 cts. per 1,000 gallons for an average of 200 gallons a day, with a minimum rate of $1 per month. For quantities in excess of 200 gallons a day the rate drops by degrees for each stipulated excess, ranging from 15 cts. per 1,000 gallons for all water over 200 and not exceeding 1,000 gallons a day, to 9 cts. for all in excess of 7,000 gallons a day.

The contract distinctly provides that it shall not be construed as granting any exclusive rights to the company, and it reserves to the city the right to buy at any time during the contract, "at such price as may be agreed upon, the water-works system, property, machinery and appliances" of the company.

The contract contains detailed provisions for increasing the number of hydrants (in some sections to one every 250 ft.); for extending the mains; for abolishing dead ends; and for maintaining certain pressures.

As a proper basis for the adjustment of rates, the report (not the contract) lays down the following items: Administration, operation, maintenance, taxes, profit on a fair valuation. The valuation should be in keeping with this particular object, and not on the same basis as for purchase by the city. This phase of the subject is discussed in detail, and the main principle adopted seems to be the inclusion of the actual cost of all those portions of the works which are still capable of full use and some portion of the cost of such unsuitable portions as 1 to 3-in. pipe, which, though undesirable, still produce a revenue. In addition, 15% was allowed for omissions, contingencies, engineering and supervision, and also interest charges on capital account during construction. In the future adjustment of rates, actual expenditures to date would of course be added, and the cost of discarded portions would be deducted. As to the "fair percentage of return on the value of the plant" after having been established as outlined, Mr. Davis suggests a range of 7 to 10%, the actual figure at any given time to be fixed by the city council in accordance with all the conditions peculiar to the locality and the time.

*But water may be used to run the city hall elevator.—Ed.

TRACTION ENGINE PRACTICE AND MANUFACTURE IN THE UNITED STATES.

In a recent bulletin issued by the Census Bureau, Mr. Edward H. Sanborn, Special Expert Agent, reports upon traction engine practice and manufacture in the United States, as illustrated by facts and figures collected for the census year 1900. Mr. Sanborn's report is a concise and instructive review of a subject upon which there is not much information, and we give it nearly in full as follows:

The manufacture of traction engines is carried on chiefly in connection with the construction of agricultural machinery, especially threshing machinery, with which they are most largely used.

The accompanying table shows the number and value of traction engines made in the United States during the census year 1900.

TRACTION ENGINES: NUMBER AND VALUE, BY STATES, 1900.

States.	Number of establishments.	Traction engines.—Number.	Traction engines.—Value.
Indiana	6	977	$914,173
Michigan	3	1,310	1,769,720
Minnesota	3	388	408,640
New York	3	418	439,256
Ohio	7	1,378	1,310,403
Pennsylvania	3	322	300,748
All other states*	6	1,339	1,242,086
United States	31	6,132	$6,385,026

During 1900, 31 establishments reported the manufacture of 6,132 traction engines, valued at $6,385,026. Michigan reported the largest value of such products, three establishments in that state having constructed 1,310 engines, aggregating $1,769,720 in value.

Portable farm engines, mounted on wheels and drawn from place to place by horses, have given way very largely in recent years to traction or self-propelling engines, which have been greatly improved. Not only do they furnish their own motive power, but they also have capacity for drawing a tender and water cart, as well as a threshing machine, and thus do not need horses either on the road or in the field. So rapid has been the substitution of the traction engine for the old type of portable engine that, according to the estimate of one large manufacturer of this class of machinery, probably 90% of all the engines used on farms to-day are of the self-propelling variety.

The work demanded of farm engines is exacting. They must travel over rough country roads, which constantly subject them to severe strains and shocks; must raise steam with any fuel available; and when used to drive machinery must transmit power without any careful setting up. It is, therefore, necessary to dispense with delicate adjustments. Few classes of machinery require such elastic construction. Their chief use is for hauling the threshing machine from place to place and furnishing power for its operation in the field. Their threshing capacity ranges from 60 to 400 bushels of wheat per hour—much depending, however, upon the size and capacity of the threshing machine. On the Pacific coast, where the traction engine has reached its highest efficiency in farm work, as many as 15 or 20 plows have been drawn by a single engine, tearing up a strip of soil from 20 to 30 ft. wide, and sometimes, under favorable circumstances, covering 50 acres per day. Harrowing and seeding are done similarly, and with even more striking speed.

Traction engines are much used in driving portable sawmills, in operating cotton gins, in grading and ditching roads, and in an infinite variety of other work for which a readily portable power is required. While the use of the traction engine is most extensive in farm work, its adaptation to road service in the transportation of heavy loads is so marked that this service promises, with the further development of the engine itself and the improvement of country roads, to increase largely.

The traction engine came into extended use in England before its utility was generally recognized in the United States, but since its introduction into this country it has been materially improved and rendered applicable to a much wider range of work. Its construction has been much improved, its size and power greatly augmented, and its economy of fuel and water notably increased. During the past ten years, in particular, this development has been marked. Formerly a 15-HP. engine was considered large, but now 25 HP. is a common size, and engines up to 35 HP. are being built. About 6 HP. is the minimum. Some of the 35-HP. engines weigh about 8 tons, and have rear driving wheels 78 ins. in diameter with tires from 24 to 32 ins. in width.

As illustrating the capacity and economy of some of the larger sizes of traction engines used in farm work, the following particulars of one type of engine constructed by one of the largest builders may be of interest. This is a simple engine with a cylinder 11 × 11 ins., carrying 140 lbs. of steam, and making 250 revolutions per minute. Although rated at 25 HP., this engine will develop nearly 100 brake HP. This size of engine is used largely for plowing, for which service the rear wheels are fitted with tires 36 ins. wide, while the tires of the front wheels are 18 ins. wide. Such an engine easily handles 10 plows 16 ins. wide, plowing furrows 6 ins. deep at the rate of 2½ miles per hour. Under average conditions of soil this work is done on a fuel consumption of about 1,400 lbs. of coal in ten hours. For the same work about 25 horses would be required.

Traction engines formerly were built with only a single cylinder, but in recent years many have been constructed with two cylinders, the chief advantage being a better balance, and therefore a steadier motion. The avoidance of dead centers, and the ability to start slowly and run at any desired speed are further advantages of no small importance.

Compounding is another new feature introduced during the past five years. The tandem arrangement of cylinders is used almost exclusively. The economy of the compound traction engine is the subject of differences of opinion among makers and users, but some claim for this type a degree of economy comparable to that generally ascribed to the stationary engine of similar principle; its popularity is evidenced by the fact that one large manufacturer built and sold over 2,000 compound engines from 1895 to 1900.

Traction engine boilers are of various types and suited to various kinds of fuel. In the eastern and southern sections of the United States coal is used almost exclusively; in the northern states wood is commonly used; while in the west straw is a common fuel. Petroleum burners have been introduced recently, and the use of crude oil promises to work a great change in the fuel question in some parts of the country. As a rule, fewer tubes are used than is customary in the construction of stationary boilers, and some makers claim advantage for large flues and few tubes, especially when straw is used for fuel. Return-flue boilers also are used to a considerable extent. As in stationary engine practice, there has been a continuous increase in steam pressures, and 150 to 160 lbs. represents about the present average.

Power is usually transmitted from the engine shaft to the driving wheels by gears, spur gears being the most common, although in some types of engines bevel gears and a connecting shaft are used. A recent innovation is the use of sprocket chains in place of gears, and great success is claimed for this method of transmission. The elasticity so essential in a machine used for such rough service is accomplished by the use of cushioned gears and spring connections for the driven gear upon the driving wheels. Connection between the engine and the driving gears is effected by means of a friction clutch, of which there are many kinds.

The link motion is used largely in the valve gear, as the ability to reverse readily is an essential qualification. Another form of reversing gear much used has a single eccentric, the strap of which has an extended arm pivoted in a wooden block placed in a guide, the angle of which can be varied so as either to reverse the engine or simply to change the travel of the valve.

Internal-combustion engines, using gasoline, have been adapted for traction purposes in recent years, but thus far they have been used chiefly in small sizes, and have not as yet demonstrated their superiority over steam where greater power is required.

*Includes establishments distributed as follows: California, 2; Illinois, 2, and Wisconsin, 2.

THE RECENT DEVELOPMENT OF TOOL STEEL.*

By Edmund L. French.

It is along the line of special steels, or alloys, made in the crucible, that the greatest advances have taken place. The makers of the old-fashioned crucible steel found that when they had produced a material with the highest amount of carbon possible, quality being at the same time of the best, they had reached the limit of cutting power in tools, and competition made it necessary for each maker to attempt something to excel his neighbor's product.

The first great advance was made by Mushet, who succeeded in melting with his charge of steel the mineral wolframite, which gave him certain regular percentages of tungsten and manganese. The steel so produced had the peculiar property of being "self-hard," that is, of requiring no heating and subsequent cooling in water to induce hardness. It had also an ability to withstand the heat developed by friction in cutting work, and the

*Extract from a paper read before the American Association for the Advancement of Science and printed in "Sparks from the Anvil."

product called "Mushet," which name is still used in some localities to designate this variety of steel, became a recognized institution. As soon as the chemist found out the ingredients of this new steel, the various makers began to imitate it.

Tungsten metal and ferro-tungsten were later made to facilitate the manufacture, and gradually chromium, molybdenum and other metals were employed in the production of this class of steel. Even uranium, titanium and vanadium are used to some extent to-day as ingredients of special crucible steels.

A large variety of combinations of iron and carbon with tungsten, chromium, manganese, nickel, silicon or molybdenum characterize the special steels on the market to-day. Every maker furnishes, besides his regular carbon steel, a self-hardening steel and an intermediate grade which may be called a semi-self-hardening. The latter is capable of being hardened in water without cracking, and suited for extremely hard cutting. The self-hardening steels cannot be brought in contact with water while hot on account of the danger of cracking. Some of the milder grades rely on the assistance of an air blast after forging to give them the proper degree of hardness for their work, and are called "air-hardening steels."

It was thought for years that the greatest degree of perfection and the limit of cutting power had been reached in the best self-hardening steels, but within the last three years new products, similar in character and analysis, have been perfected, with capabilities of high speed work which far surpass the old. Many of the latter steels owe their high speed qualities to special heat treatments given the tool after forging, while some of the newer products are of such combinations chemically that no treatment, or only a simple one, is necessary. It would be out of place to give a minute description of these steels at this time, for their ingredients and process of manufacture are secrets, and the property of the makers.

These high-speed steels have worked a complete revolution in modern engineering, necessitating the building of new and more powerful machine tools, and nearly doubling the output of shops where they have been adopted. All the best makes of high-speed steels show ability to withstand the heat engendered in heavy lathe and planer work to such a degree that it is a common sight in machine shops where the latest high-speed steels are used, to see a tool doing heavy cutting work with that part of the steel where the chip curls off actually red hot. Here comes in the distinction between a plain carbon steel and the high-speed self-hardening product—when a tool made of the former becomes so heated by work as to show the temper colors, it softens and the cutting edge is quickly rubbed off, while a high-speed tool similarly heated retains sufficient hardness to do the work required.

Until recently the extensive use of self-hardening steel has been confined to extremely simple forms of tools, where all the work necessary to fit them for service could be done by forging and grinding to shape. Now, however, there have been perfected processes of annealing which admit of self-hardening steel being as easily machined as most of the ordinary carbon grades. The high-speed qualities of the steel, as found in lathe and planer tools, can thus be utilized for cutters of all kinds, complicated or simple in pattern, at a great saving of time through the increased amount of work such tools are capable of turning out. The greatest advantage, however, which such a steel possesses over the ordinary water-hardening varieties lies in the fact that there is absolutely no danger of loss in the hardening bath, where so many costly tools meet their end, for it is only necessary to heat such a steel to redness and lay it aside to cool, when it will have regained the hardness it possessed before annealing.

While there has been an important advance in the quality and efficiency of tool steel, for which the manufacturer is responsible, the user has also been making rapid progress along the line of proper scientific treatment. Owing in a great measure to the now generally understood modern theories of hardening, the consumer has been in a position to gradually educate himself to a point where he knows the necessity of accurately regulating the heats employed in hardening and tempering. In every establishment where fine tools are manufactured on a large scale, there will be found accurate methods of handling the steel to get the best results. I have had occasion to observe the workings of one heat gage in particular, by means of which the heat used in hardening is so delicately regulated that a variation of 10 degrees Fahrenheit is readily distinguishable, even to the untrained eye, and tools are rapidly heated and hardened in large numbers with perfect accuracy. Various forms and makes of hardening furnaces, tempering baths, pyrometers and heat gages have reduced hardening and tempering to an exact science.

The result of this accuracy on the part of the consumer is that the up-to-date manufacturer of fine tool steel is able to specialize, as it were, giving to each customer a temper of steel exactly suited to the kind of tool required. By "temper" is meant percentage of carbon. In other words, where according to old-fashioned "guessing" methods of hardening it would be unsafe to furnish anything but a medium or "safe" temper, fairly well suited for any kind of a tool, it is now possible to give the tool-maker one kind of steel for a reamer, another for a cutting die, another for a lathe tool, etc., thus taking advantage of the greatest cutting power and endurance of steel for any given purpose. The use of the microscope for the purpose of ascertaining the proper heats for hardening and annealing has done much to educate the steel user in proper treatment.

DIFFICULT WORK IN REPAIRING A SWISS RAILWAY TUNNEL.

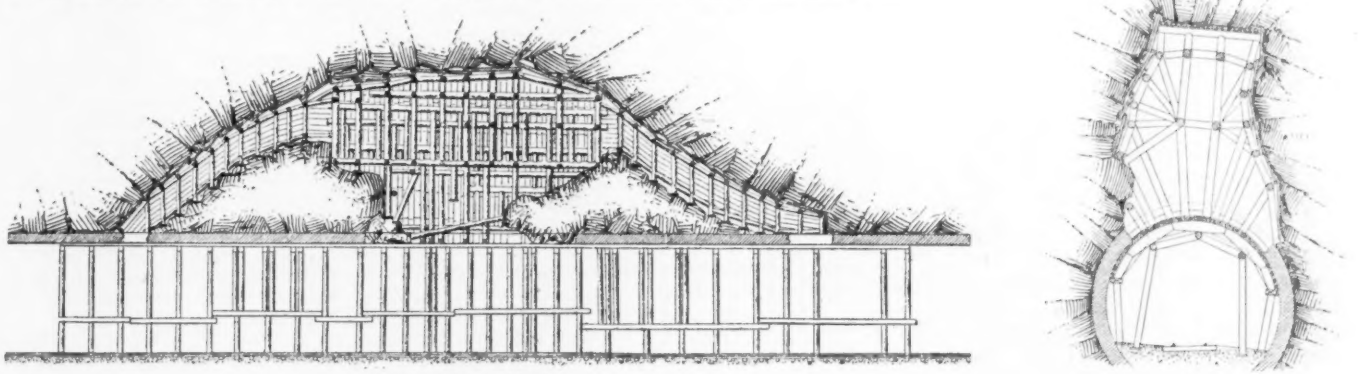
The Cornallaz tunnel, on the line of railway running from Lausanne to Berne, in Switzerland, is a masonry-lined tunnel some 1,600 ft. long. On May 2 of the present year, during a spell of very wet weather, the roof of the tunnel caved in, at a point about 500 ft. from one end, for a length of 30 ft., forming a lofty cavity and entirely blocking the tunnel-opening itself. The tunnel at this point runs through alternating beds of marl and sandstone. The break occurred in the transition region between two such strata, and the rock was there so badly seamed in character as to be finally broken up into separate blocks or boulders. Normally, the seams and spaces between the blocks were filled with small material and earth, cementing the whole mass together more or less, but the long continued heavy rains just preceding the break had caused the increased amounts of ground water flowing to wash out this fine material from between the blocks; the rock mass, thus deprived of its coherence, rested its full weight on the arch of the tunnel and crushed it in.

After the first collapse, falls of rock continued for several days, until the hole extended about 25 ft. above the original roof of the tunnel before active repair work was begun.

The situation at this time was such as to make all ordinary methods of dealing with the break appear insufficient. Several tunnel specialists of much practical experience were consulted, and finally the work of repair was entrusted to Fougerolle Bros., a firm of general tunnel contractors, who had suggested what appeared the best method of handling the work. We abstract a short description of the method employed from the "Schweizerische Bauzeitung."

As a preliminary proceeding the masonry lining of the tunnel was securely lagged and timbered for some distance either side of the break. The next part of the work, clearing the tunnel and supporting the rock so that the actual reconstruction could begin, was the point of serious difficulty; blocks of stone were still dropping from the roof of the cavity, thus showing that the danger from loose rock was not yet past; further, the pile of debris in the tunnel bore gave considerable support to the possible loose masses of rock directly above and adjacent, in such a manner that it was considered impracticably hazardous to remove this support before the larger part of the bracing and securing had been done.

The method of attack indicated by these conditions was to get at the roof of the cavity in the rock, secure this by timbering, and work downward; the execution of this work proved exceedingly delicate and tedious. About 35 ft. back either way from the break, a hole was pierced through the roof arch and a narrow heading or drift started, upward and toward the break. These headings were quite difficult to drive, particularly one of the two, which passed through the same kind of loose rock aggregate as that which caused the collapse. Both headings were timbered securely. Their shape and position may be understood from the accompanying drawing, which shows the temporary work when completed. When they reached the cavity, poling-boards were driven forward over the last cross-frame and their ends supported by a frame supported on props from the pile of debris below. Another set of poling-boards was driven out and similarly supported, and this process continued, at the same time filling in the space behind the boards with brush. In this way the entire roof of the cavity was supported by timbering and rendered safe, and the work then proceeded downward. Longitudinal stringers were placed as shown in the cross-section, and braced together and to the cross frames, and as the debris was cleared away they were successively supported by props and braces upon the rock below. As the lower masses of the fallen rock were reached, the work became more difficult, not only because of the large amount of timbering resting on supports that had constantly to be shifted, but also because large boulders of the rock were encountered, which had to be cut through by hand or broken up by blasting, using only the smallest possible charges.



Longitudinal Section. Cross-Section.

METHOD OF REPAIRING A ROCK FALL IN A SWISS TUNNEL.

Finally, the work of clearing away reached the point where centers could be set and lagging placed for building the arch ring. A form of centering was used which left space for the passage of trains, and traffic was resumed on June 24, after an interruption of 53 days. At the time the note from which we quote was written work on the arch ring was under way. The reconstructed arch ring is four feet in thickness, built of cut stone laid in cement mortar. The outside of the tunnel arch will be covered by a waterproofing course, and outside of this a course of masonry laid dry, 8 to 16 ins. thick, will be placed. In the side walls weepholes are left every three or four feet, draining to the main ditch. The timbered cavity above the arch ring and the temporary drifts will be filled with cinder concrete packed in.

ENGINEERING NEWS

A Journal of Civil, Mechanical, Mining and Electrical Engineering.

Entered at the New York Post-Office as Second-Class Matter.
Published every Thursday
at St. Paul Building, 220 Broadway, New York, by
THE ENGINEERING NEWS PUBLISHING COMPANY

GEO. H. FROST, ... PRESIDENT.
D. McN. STAUFFER, ... VICE-PRESIDENT.
CHARLES WHITING BAKER, SECRETARY AND MANAGING EDITOR.
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ALFRED E. KORNFELD, New York,
M. C. ROBBINS, Chicago,
S. B. READ, Boston,
} ADVERTISING REPRESENTATIVES.

PUBLICATION OFFICE, 220 BROADWAY, NEW YORK.
CHICAGO OFFICE, 1636 MONADNOCK BLOCK.
BOSTON OFFICE, 170 SUMMER ST.
CLEVELAND OFFICE, OSBORN BUILDING.

FOREIGN AGENTS.

C. MITCHELL & Co, Snow Hill, Holborn Viaduct, LONDON.
RUDOLF MOSSE, BERLIN and HAMBURG, GERMANY.
JOHN F. JONES, & CIE. 31 Rue de Faubourg Montmartre, PARIS.

SUBSCRIPTION RATES: United States, Canada and Mexico, One Year, $5.00; 6 months, $2.50; 2 months, $1.00. To all other countries in the Postal Union: Regular Edition, One Year, $7.80 (31 shillings); Thin Paper Edition, One Year, $0.31 (26 shillings). SINGLE COPIES of any number in current Volume, 15 cents.

In requesting change of mailing address, state BOTH old and new address; notice of change should reach us by Tuesday to be effective for the issue of the current week. The number on the address label of each paper indicates when subscription expires, the last figure indicating the year and the one or two preceding figures the week of that year; for instance, the number 323 means that subscription is paid to the 32d week (that is the issue of Aug. 6) of the year 1903; the change of these figures is the only receipt, unless one is sent by special request.

ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

Nearly ten years ago we illustrated in this journal one of the largest mine-pumping engines ever constructed in the United States, and in editorial comment expressed the opinion that the day of the old-time Cornish pumping engine for mine drainage had passed and that electricity was the future power for mine pumping. At the time several correspondents dissented from this opinion and defended the old-time direct-acting machinery.

At the present day, of course, electric power for mine pumping is well established, as sound engineering practice; but we doubt whether engineers generally appreciate the saving which is made by its introduction. We find some interesting figures concerning this saving in a paper read at the recent meeting of the Iron & Steel Institute by Mr. D. Selby Bigge, of Newcastle-on-Tyne, England. He cited three examples of the substitution of electric power in place of steam for raising water in collieries. In two cases the annual saving made by the electric plant in fuel alone exceeded $7,500 a year, and in the other case it amounted to $15,000 a year.

In one of these collieries in the South Durham coal field, the electric plant was originally put in, not to save fuel, but because the old spear-rod pumps took up room in the shaft which it was desired to utilize for an additional hoisting cage. About 1,000 gallons of water had to be lifted per minute against a 400-ft. head, and this work is now done by two 11 × 8-in. three-throw pumps driven by electric motors, with a saving, as before noted, of $7,500 per annum.

In a Northumberland colliery an electric pumping plant was installed at a cost of $15,000, and the saving in fuel over the old system amounts to from $8,000 to $9,000 a year.

Some figures of the actual fuel consumption are given for a Scotch colliery originally drained by a spear-rod pump to the shaft bottom and two duplex direct-acting pumps located underground with steam pipes down the shaft. This plant required seven men to run the pumps and the coal consumption was 14 tons per day. An electric three-throw pump was substituted and the coal consumption was cut down to 2¼ tons per day while the whole plant is cared for by three men. Here again the electric plant will pay for itself in less than two years by its saving.

These figures are not surprising at all when one considers the ponderous character of the pumping machinery for driving deep shafts when designed according to old-time precedents. The huge engine at the Ontario silver mine in Utah, described and illustrated in our issue of Nov. 29, 1894, has a pump rod of Oregon pine, 16 ins. square and 1,000 ft. long. On the Comstock lode at the Union Shaft there is a pumping engine which drives a pump rod of 18 × 18-in. Oregon pine, 2,618 ft. in length. The total weight in motion when this engine is running is 1,620,500 lbs., and it lifts 750 gallons of water per minute to a height of 1,180 ft. At the Yellow Jacket shaft is a still longer pump rod, its total length being 3,055 ft. In a recent paper by Mr. Leon M. Hall before the Pacific Coast Electric Transmission Association it is stated that the combined Cornish pumps on the Comstock lode moved 2.7 miles of pump rod, and that for every gallon of water pumped, a weight of 2,230 lbs. had to be started and brought to rest, an average of nine times per minute. The total cost of these pumps was over $2,500,000, and the cost of their operation was $34.13 per HP. per month with wood at $10 per cord, equivalent to $410 per HP. per annum.

Surely nothing can be clearer than that electric mine pumping for all deep shaft work must supersede the old-time ponderous and enormously costly system. The comparison of the simple stationary wire cable carrying an electric current with the ponderous wooden timber as a means of transmitting power down a mine shaft is sufficient to convince even a layman of the great advantages which electricity offers.

It is of interest to note, too, that the use of electricity will doubtless make possible the working of mines to far greater depths than could be reached without its aid; and it will thus enable the world to utilize stores of mineral which would otherwise be inaccessible.

Apropos of the letter in our correspondence column by an engineer who complains of the inadequacy of engineers' compensation, we note with interest the application of Superintendent Stewart, of the New York Department of Buildings, for an increase in salary to the Chief Engineer of the Bureau and his two assistants. At present the great and wealthy City of New York is paying to these men salaries of $2,250, $1,650 and $1,500 a year, respectively, and it is asked that these be raised to $3,000, $2,250 and $2,100. The "New York Times," commenting on this request, says that "if the Chief Engineer and his two assistants are fit for the places they occupy, they are worth a great deal more even than the Superintendent asks for them."

A great deal of literature has been written—and this journal has contributed its full share to its publication—upon the bearing power of piles. All the resources of mathematical lore have been brought forward in the attempt to develop a rule by which the engineer could compute the load that might safely be imposed upon a pile foundation. Nearly all this discussion, however, so far as we recall, has ignored what we may term the limit of safe driving. There are plenty of specifications which describe the weight of hammer to be used and the penetration which must be attained before driving shall stop; but we recall none in which any limit is set to the driving, and it seems to be assumed by the theorists that a pile is an "indestructible body."

In our review last week of the Charleston dry-dock specifications, we commented on the requirement that piles should be driven by a 3,000-lb. hammer falling freely 20 ft., and we raised the question whether piles would stand such blows without injury. As evidence on this matter we have now received from an engineer of long experience in contracting work and a well-known member of the American Society of Civil Engineers an account of tests made to shed light upon this matter. We print his letter below and believe that it deserves the careful attention of engineers engaged in pile-driving work:

Sir: Some years ago I conducted a series of experiments on the resistance of piles to driving, the results of which will bear out the criticism which you make of the pile-driving paragraph in the specifications for the Charleston dry-dock.

The work was done under the direction of Mr. George S. Greene, Jr., M. Am. Soc. C. E., then the Chief Engineer of the Department of Docks, New York city. It had been noticed that the piles were apparently suffering severely from the very heavy blows to which they were subjected, and in order to determine just what damage was being done, and the remedy therefor, authority was given to make the following experiments:

A lot of piles were selected of about the same dimensions, measuring about 6 ins. to 8 ins. in diameter at the point, and about 12 to 15 ins. diameter at the butt, and all running in length from 40 to 50 ft. The piles were generally of spruce or yellow pine. The material into which the piles were driven was a mixture of clay, sand, gravel and small cobbles, offering a gradually-increasing resistance to the penetration of the piles. The weight of the hammer employed was about 3,000 lbs. It was allowed to fall freely with the rope attached.

The object of the tests was to determine the height of fall of the hammer which could be employed with safety to the pile, so as not to impair its integrity either by brooming it at the head or at the point, or breaking it at some intermediate point. The first piles were driven as had been the custom by letting the hammer fall from the top of the ways until the maximum fall reached about 25 feet, after which the fall was not increased. With the successive piles driven the fall was gradually diminished. Each pile driven was pulled up by a 100-ton derrick and examined. It was found that nearly every pile that was driven with a fall exceeding 10 feet was more or less injured, either by a very bad brooming of the point, or by a break at some distance above the point. It was found that a ten-foot fall could be depended upon not to injure the piles. In order to make sure against the fall being greater than this, the limit was placed in the instructions to the foreman at 8 ft., so that for many years the specifications for pile-driving was that a pile should be driven with a fall of a 3,000-lb. hammer not exceeding 8 ft., and until the penetration should not exceed 1 in. in the last three to five blows, as the circumstances might warrant.

An extensive subsequent experience in pile-driving under many other conditions has confirmed the result of these experiments, namely, that a fall of a 3,000-lb. hammer greater than 10 ft. is very uncertain in its result, and more likely than not to injure the pile.

Yours very truly, "Contractor."

We invite correspondence from any of our readers who can furnish further data upon this important matter.

The revolution in machine-shop practice by which the tool is taken to the work instead of the work to the tool was discussed in an editorial in our issue of Feb. 21, 1901. A remarkable illustration of the rapid increase in the use of portable tools is found in figures furnished to us by Mr. J. W. Duntley, President of the Chicago Pneumatic Tool Co. In 1895, the sales of this company amounted to $8,000. In the current year they will approximate $3,000,000. Of course, a large proportion of this business represents the substitution of mechanical power for human muscle in the operations of riveting, chipping, boring, reaming, etc. After making all allowance for this, however, it is still evident that a great change is in progress in the use of portable tools in place of fixed tools, a change that should be fully understood by every engineer charged with responsibility in the design of any manufacturing plant.

A remarkable locomotive performance is recorded by London "Engineering," being a record of 2,000,000 miles run in 20 years, or an average annual service of 100,000 miles. The engine is the "Charles Dickens," of the London & Northwestern Ry., designed by Mr. F. W. Webb, and it has been used almost exclusively in fast express service between London and Manchester. The locomotive was turned out at Crewe on Feb. 6, 1882, and has been "laid up," which we suppose means in the shops, 12% of the time since. Its cost of maintenance has averaged only 2.56 cts.

per mile run, which very low figure is in part explained by its very high mileage. The average annual passenger mileage of English locomotives is given by our contemporary at only 20,000 miles, hence this locomotive has given about five times the average service. The low average mileage in England is due chiefly to the short runs in local and suburban traffic which constitutes the great bulk of the passenger business. American passenger locomotives average over 30,000 miles, but one would probably have to look far for an engine in this country which has made 2,000,000 miles in 20 years. American express locomotives which were built as long ago as 1882 are most of them doing menial work hauling local trains or have been turned over to branch lines. So far as daily service is concerned, however, a number of American locomotives in fast express service must be making at present as high a daily mileage as the "Charles Dickens." The total coal consumption of this engine since it began service is given as 27,486 tons, equal to an average of 32 lbs. per mile, including the amount used for lighting fires. In this respect it is safe to say no American locomotive can approach its record.

THE PRICE CONTRACTORS CHARGE FOR CARRYING RISKS.

We discussed in our last issue an attempt to place upon a contractor for a government dry-dock an undue measure of risk and responsibility; and we urged that such an attempt was certain in the long run to prove ineffectual and to result in unnecessary expense to the public.

In the discussion last week at the American Society of Civil Engineers' meeting exactly the same principles were brought forward in connection with an entirely different field of engineering work, the letting of municipal contracts for asphalt paving. The arguments presented by the members who took part in the discussion were directly in line with those set forth in our editorial last week; and the sentiment was unanimous that the attempt to impose an undue and unknown risk upon the contractor was sure to work to the disadvantage of the city. As one well-known engineer expressed it: When a contract contains an element of guesswork the contractor—if he is a responsible and experienced man—will guess enough to cover the worst conditions. If the conditions prove as bad as he anticipated, he still comes out whole; and if they prove better, he makes a large profit. Thus the inevitable result of the attempt to place all the risk on the contractor is to make the city pay the highest price for its work. The result of asking the contractor to take the risk of striking rock in a trench, for instance, is that the city will have to pay the price for rock anyway, whether it is found or not.

Again, we pointed out last week the inherent injustice of telling a contractor to build a dry-dock according to detailed plans and specifications, and at the same time asking him to guarantee that the completed structure shall be a success. Similarly in asphalt paving, engineers are now specifying in exact detail the method of performing every part of the work and at the same time asking the contractor to guarantee that a pavement so made and laid shall be a good and durable pavement.

Of course it will be said in extenuation, that the guarantee is asked in each case to make sure that the workmanship shall be first-class. There is a common idea, in fact, that the entire responsibility for the workmanship ought to rest on the contractor. But let us ask in all fairness what better facilities the contractor has than the engineer to ensure good workmanship?

In considering this subject we must take account of the conditions under which great engineering works are now carried out. Contracting firms or corporations with large capital, extensive plant and complex organization are necessary to handle such enterprises. The small contractor, working often as a foreman with his own men, can well be held responsible for workmanship because he can personally see that good work is done. The great contracting firm or corporation is in an entirely different position. A "contractor" of this sort must depend, like the engineer, on systematic inspection to insure good workmanship. Particularly is this true under modern labor conditions. Perfectly honest and reputable contractors have poor work done under their direction entirely contrary to their desire and against express orders. Sometimes competent foremen will slight work for the sake of hastening the rate of progress and making a reputation for hustling, or even for the sake of getting ahead of the engineer. As for the ordinary workmen, it is the commonest thing for them to cover up imperfect work.

The only safeguard against this is systematic and competent inspection, and this it is and ought to be the business of the engineer and not the contractor to provide. The responsibility is on the engineer to pass upon the sufficiency of the work as it progresses and it is his business to carry that responsibility alone and not attempt to unload part of the burden on the contractor.

But here it should be said that the blame for the attempt to load every burden upon the contractor is in a majority of cases, we believe, to be laid not on the engineer but on the attorneys, or other supposed sentinels of the public interest, who have a voice in drafting the contract. It is a common idea that everything extra which can be loaded upon the contractor is a way of getting something for nothing. "Let him take the risk, he won't charge any more for it," is the commonly expressed idea. "Let him guarantee the perfection of the work, instead of going to the expense of hiring inspectors" is another plea of the would-be economist. The engineer, who knows better, acquiesces; and who can blame him, for he is well aware that if he were to urge that the work of inspection be left in his hands, where it belongs, he would be given enough money to employ half enough inspectors and to pay them half what they were worth, and even then his well-meant efforts to protect the public interest would be construed by some zealous public critic as an attempt to magnify the importance of his own office and make places for his friends!

Returning now to the discussion before the American Society of Civil Engineers, a point on which especial stress was laid was the unwisdom of long-term guarantee requirements in letting asphalt paving contracts. If there is one among our readers who is a believer in the policy of letting asphalt paving contracts with a long-term guarantee, we strongly advise him to obtain and carefully read the report of this discussion when it appears in the Society's "Proceedings," and if he reads with an unprejudiced mind, we are confident his opinion will be changed.

Of course it is easy to see how the guarantee system grew up in the asphalt paving industry. The companies who were exploiting this paving and making large claims for its durability could not well object to guarantee clauses when they were proposed. In fact, so long as the entire responsibility was on them for material and workmanship, a guarantee of maintenance by the contractor was perhaps a necessary evil. These, however, are the conditions of the past, not of the present and future. Engineers can now specify exactly how they want an asphalt pavement made and laid. To complicate the simple matter of carrying out this work with an agreement to maintain the pavement for a period of ten to fifteen years, works evil in a great variety of ways and should be strongly opposed by engineers.

There is an aspect of the letting of contract work open to free competition which often seems to be overlooked by engineers. Did it ever occur to the reader that the engineer who drafts a plan, specification and contract, may be likened to a manufacturer preparing goods for a market? It is the duty of the engineer to make his product attractive to contractors, so that a large number may be induced to bid and his client may get the work done at a low price. We do not mean by this, of course, that an engineer is to sacrifice the character of the work. What we mean is that he should make it possible for the contractor to know in advance exactly what will be expected of him, and shall reduce to a minimum the risks and chances of loss in connection with the work.

This seems so simple and evident that there ought to be no question concerning it. Yet how frequently is it violated. A current example is a sewer tunnel for which bids are soon to be received, and for which contractors are invited to submit bids per lineal foot complete, regardless of the nature of the material encountered. The city has made no borings or investigations whatever, and will not do so. Contractors are at liberty to find out what they choose for themselves. Let us see what the natural result of this plan will be. First, it will limit the number of bidders. Few contractors will go to the expense of making borings along the route of the tunnel, on the mere chance that they may obtain the contract. Second, any contractor who does undertake to investigate will spend as little as possible on the work, since there is only a chance that he will be the successful bidder. He will find out what he can without too much time and trouble and guess at the rest, and he will then make a bid to cover the worst conditions likely to be encountered. Thus, if things turn out badly he will come out whole, and if the material turns out favorably he will make a large profit at the city's expense. Besides this, if prospective bidders are all permitted to make borings, sink test pits, etc., it will be pretty well known in advance who are to submit bids, and the chances are excellent that the bidders will form a pool among themselves and submit bids in accordance with previous agreement.

Finally, in our argument we have throughout contended that the effect of introducing risk and uncertainty in specifications for contract work was to increase the cost of the work to the public. In support of this position we believe we may fairly cite the bids for the new dry-dock at the Norfolk navy-yard, which were printed on p. 112 of our Construction News Supplement last week. The specifications for the Norfolk dry-dock were very similar to those for the Charleston dry-dock, which we criticised in our last issue. In these specifications it is stated that the limit of cost for the entire work covered by the specification is about $850,000. The bids received ranged from $1,214,677 to $1,320,000. Is it not a fair conclusion that contractors require a large margin over engineers' estimates where such risks are thrown upon them as we have pointed out?

LETTERS TO THE EDITOR.

Concrete Reinforced with Expanded Metal for Permanent Bridge Floors.

Sir: Referring to the description of a test to destruction of a 6-in. slab of concrete reinforced with expanded metal, in Engineering News of Aug. 7, 1902, I would say that a second test has just been made of the same materials under the same conditions, except that the thickness of the second slab was 4 ins. and that the concrete was mixed in the proportions of 1 cement, 2½ sand and 5 broken stone. The slab was made on July 22 and broken Sept. 11. The load required to break the slab was 22 tons as against 28 tons for the 6-in. slab. As a result of these tests, this system of construction will be used for a permanent floor of one of the city bridges this year.

The advantage of this construction over buckle plates for city bridges of short span where I-beams can be used is that all of the metal is entirely covered and protected from rust. This is important where the iron is subjected to steam and gases from engines or sewers. One of the lower flanges of a 20-in. plate-girder bridge built in 1890, near the mouth of a sewer, was entirely eaten off by the gases from the sewer and had to be replaced last year by a permanent structure. Yours truly,

O. W. Connet, Assistant City Engineer.

Baltimore, Md., Sept. 20, 1902.

Reheating Between the Cylinders of Compound Engines.

Sir: The writer has been much interested in the paper in your issue of Aug. 21, describing an engine test to determine the effect of reheating between the cylinders of a compound engine, and on the letter in your issue of Sept. 4, on the same subject.

While the letter touches upon the conditions controlling the economy, it quotes a test upon a make of engine on which *usually* the reheating receiver is a reheater only in name, and consists of a reheater with short tubes and the reheating so small as to give no economial results. The reheating surface is too small to be of benefit in the case of the test which you published Aug. 21. It is a pity that so much energy should be expended upon tests and the vital points omitted, or at least not published.

The writer has seen no account published on the effect of reheating in which the reheating surface, and the condition and temperature of steam entering and leaving the reheater has been included.

With this data before one, it is possible to form an intelligent opinion as to the result of tests; otherwise they are useless, as in the case of the tests mentioned in your columns.

When the engines and reheaters are correctly designed, there is no question as to the economy being greater with the reheater than without it. Very truly yours,

Josiah Harmar.

5th St. and Washington Ave., Philadelphia, Pa.,
Sept. 17, 1902.

Calculating Columns Under Eccentric Loads.

Sir: I should like to ask space for an explanation of the method of figuring structural steel columns under an eccentric load.

For instance in a warehouse, material may be piled up on the floor on one side of a column, while the floor on the opposite side is empty. The resultant load would then act to one side of the center line of the column and the effect on the column would likely be worse than if the floor was loaded all around the column. In the possible case of a building of several stories, each with the load only on one side of the columns and that the same side, the cumulative effect on the bottom column of these eccentric loads would seem to be worth consideration.

A rational formula for a short strut under eccentric load is

$$p = \frac{P}{A}\left(1 + \frac{x\,a}{r}\right)$$

where p = safe unit fiber stress,
P = the total load.
x = the eccentricity of the load,
a = distance from the neutral axis of the section to the most strained fiber,
r = radius of gyration of the section.

Could this formua be safely applied to the case of a column of ordinary ratio of length to radius of gyration under these conditions? Will you also kindly indicate the correct method to use? Very respectfully yours,

F. D. B.

Akron, O., Sept. 13, 1902.

(We pass the query on to our readers. There is good reason to suppose that the matter of eccentricity of column connections is given much less attention by practical designers than it deserves. The beamwork in front walls is an instance of especial temptation to neglect eccentricity—Ed.)

The Present Status of the Sewage Disposal Problem in England.

Sir: Referring to the foot-note on p. 154 of your issue of Aug. 28, in which issue appeared an article with the above title, I should like to call attention to the fact, that only half of our sewage is at present filtered. This accounts for there being 10 samples above the Mersey & Irwell limit. The nine samples below the limit were filtered samples and were satisfactory.

At places in this watershed, where all the sewage is not treated, the inspectors take a sample of the filtered effluent and also one of the tank effluent.

According to the foot-note, it would appear that practically 50% of our final effluents were good and 50% bad, but this is not the case, as you will see from the foregoing part of this letter. Yours faithfully,

A. S. Wylie.

Oldham Corporation Sewerage Works,
Oldham, England, Sept. 9, 1902.

(The sewage filters at Oldham are of the contact bed type.—Ed.)

Sir: It is unfortunate that all the contributors to the discussion on Professor Kinnicutt's paper were speaking from hearsay, and that the professor's recollections seems perhaps a little dimmed by lapse of time, seeing that the practical objections he suggests are really non-existent. I am hoping that Professor Kinnicutt will see his way to supplement his most valuable tank researches by an investigation into the practical working of the continuous filter, when I have no doubt he will be able to endorse the very favorable opinions that are now reaching me from all parts of the world. Yours faithfully,

F. Wallis Stoddart.

Western Counties Laboratories,
Bristol, England, Sept. 8, 1902.

Primary and Secondary Considerations in the Disposal Sewage.—Continued.

Sir: The omission of two or three words in my previous letter in your Sept. 18th number, under the above heading, rendered me fairly open to the mild reproof which you administer in your editorial comment upon it. In my remarks upon the "scoffing character" of some comments upon sewage disposal by the daily papers, I referred entirely to those made by correspondents to Engineering News, and not by the editor thereof. I read carefully, and with hearty approval, your notes in the issue of Sept. 11th, and considered that I was backing you up in my letter, rather than insinuating "discourtesy" on your part.

With pen in hand, I cannot resist availing myself of the opportunity of expressing my satisfaction with your editorial, contained in your issue of Sept. 18, headed "Engineers, Contractors and Specifications." Your criticisms upon the clauses which you cite from government specifications are just and to the point. Such specifications overshoot the mark. I believe their practical result is this: Dishonest or reckless contractors pay little attention to them, trusting to luck in cases to which they would apply, while honorable and conservative parties guard themselves by raising their figures, with the result that the work goes to the tricky and irresponsible bidder. They are calculated to secure poor work, or high prices.

E. Sherman Gould.

Yonkers, N. Y., Sept. 19, 1902.

Engineers, Contractors and Specifications.

Sir: Your treatment of the subject of specifications and ambiguous clauses therein in your last week's editorial will meet with the most hearty approval of every man who has ever taken the contractor's end of a piece of engineering work.

In so far as holding a contractor responsible for the stability of a structure, built exactly according to engineers' specifications, is concerned, I would say that there are several judicial decisions to the effect that a contractor cannot be held responsible. Such clauses in a specification are therefore not only morally reprehensible, but legally incapable of enforcement.

The same may be said of many another clause in specifications. From which we conclude that the "law of contracts" is a subject very lightly touched upon, if touched upon at all, in most of our engineering schools.

One of the most common of these illegal clauses, if we may so term them, is the one making the engineer the final referee in case of dispute over the meaning of the terms of the contract, as if it were possible to thus bind a contractor not to appeal to the courts. However, all well-informed contractors are aware that such clauses are mere bluffs, but nevertheless they cannot be ignored, for they may lead to a lawsuit with its consequent expense.

The specifications for work under the N. Y. State Engineer, which I have had occasion to criticise in your columns from another point of view, and indeed almost all specifications for public work, are so ambiguously worded that under them it is possible to "take the hide off" any contractor who falls under the displeasure of the engineering department for any reason whatsoever; and I speak whereof I know when I add that he is ordinarily a very foolish man who undertakes to do work under such specifications unless he has a "political drag." Those who have made money on state contracts in the last six years I can enumerate upon my fingers, and without exception there has been some member of the successful firm who is actively engaged in politics.

To make matters worse if possible, the act relative to the awarding of contracts reads that "the contract shall be awarded to the lowest responsible bidder." That one word "responsible" entirely negatives the intent of the act, for the courts have repeatedly held that the awarding officer or board is the sole and final judge as to who is, or is not, "responsible." Acting in the semi-judicial capacity vested in him by the act referred to, the state engineer has in more instances than one within the last two years awarded contracts to others than the lowest bidders. Perhaps he has acted wisely, perhaps not. I am glad he did so in one case where I was associated in bidding for the first time with another civil engineer (worth several hundred thousand dollars), for while I had had experience in road building, I doubt not I should have failed to complete the contract within the time limit, for the higher bidder to whom it was awarded himself failed to do so, though regarded as a "whirlwind," and an astute handler of men.

Assuredly the right to decide off-hand whether a firm is "responsible" or not should never be vested in a single officer to say the very least, and when one reads the scandals connected with awarding contracts in Philadelphia, one questions whether any body of political officeholders should be vested with authority to determine a bidder's "responsibility."

A satisfactory solution of the problem is admittedly difficult, but it would seem that if the contractor furnishes the bond of a surety company, he is responsible in their eyes anyway; and who is more apt to look closer into a contractor's financial and business ability than the surety company which signs his bond? If, in addition to a surety company bond, it is further specified that certain portions of the contract be completed within a certain time, I see no reason why a contract for public work should not always be awarded to the lowest bidder. I have never seen a contract without a time limit, but the date fixed has always been for the final completion of the work. Now who can foretell whether a contractor whose work is apparently moving slowly will be able to hurry it along later so as to finish in time or not? The contractor often maintains that he will finish in time, the engineer that he will not; and, being the judge, the engineer sometimes takes the work out of the contractor's hands, acting under some such contract clause as you have quoted, thus—lawsuit.

Why, for example, is work not divided into sections horizontally, or vertically, or otherwise, and a time limit assigned to each section? Ambiguity and uncertainty would thus be eliminated, in so far as rapidity of work is concerned. And engineers cannot be too often told that every ambiguous word in a specification causes an honest contractor to add to his bidding price—or not to bid at all.

Yours truly, Halbert P. Gillette.

Rochester, N. Y., Sept. 18, 1902.

Concerning the Compensation of Engineers.

Sir: A source of never-ceasing discussion among engineers is the subject of inadequate salaries. A man after four years in a technical school, and perhaps an equal number as an "apprentice engineer," finds himself able to "command a salary"—when he can get a job—of about $75, or just what a hod-carrier belonging to the union in Pittsburg now earns. It is said in explanation that the supply of engineers exceeds the demand.

Pray tell us, is the material of which hod-carriers are made a rarer article than the clay that forms engineers? Or does it, perchance, require more years of training to answer to the call of "mort here," than "up a hair, down a hair"?

To a man up a tree the existence of a "union" in one case and its absence in the other is the real cause of difference between wages and salaries—in favor of wages.

Are not engineers high up in the profession largely to blame for low salaries paid subordinates? Is not the desire to keep within 4% or 5% for engineering and so win a reputation (?) for economy for themselves one of the motives that actuates chiefs of departments?

I know a technical graduate who worked two years on one of our large railways as rodman for $35 a month. He did work calling for quite as much skill as carpentry or machine-shop work, but you see he was "getting experience" and the railroad company could not see its way clear to pay much to a man "getting experience." If it were the custom to cut a man's salary down because he is "getting experience," don't you think that even some chief engineers might stand a slight cut in theirs? This "getting-experience" talk is an old ruse, but it doesn't go with young mechanics belonging to a union. Why does it go with young surveyors, draftsmen and computers? Simply because through absence of organization they are imposed upon.

But it would be unprofessional for civil engineers to belong to a union? Well, if so I know quite a number of young men who would sooner be "unprofessional" to that extent at $8 a day than "professional" at an equal sum per week.

The terms professional and unprofessional, with all that they imply, have been borrowed from the professions of law and medicine that no more resemble engineering than a chicken does an eagle—with all due deference to the "learned professions."

It used to be unprofessional for an engineer to take out a patent, because patenting medicines is unprofessional. Now, an engineer may apply for a patent without being unprofessional—though heaven only knows what he will do with it when he gets it. Other engineers will not use his design, and he himself usually cannot.

Gradually we are coming to recognize that there are great essential differences between the two "learned professions" and the great scientific profession. For example, neither doctors nor lawyers make a practice of selling their services by the day or by contract, as engineers do. Ask an attorney what he will charge you for a prospective service. "Can't tell. It will depend"—upon your pocketbook's capacity. Get a surgeon to solve the equation of life for you. He will let X stand for the rays with which he will illuminate your sewer system, and U must stand for the "touch" that will read: "For services rendered $500."

Engineering being an exact science, the public demands exactitude even to the bills that are to be rendered, and wants to see the bill before the work is begun.

I recall being asked how much I would charge for subdividing a section of land. After a few moments of figuring—how much my prospective patron would consider me worth—I replied "Fifteen dollars," a very modest estimate of my worth, in fact. Up went his eyebrows. "Fifteen dollars, indeed! Why, the oldest engineer in town has offered to do the work for twenty." "Well," I replied, "he wins. Take the work to him. We engineers, out of professional courtesy, always insist upon work going to the highest bidder in such cases as this, especially when the highest bidder is an older man."

Who ever heard of doctors bidding for the privilege of bleeding a man?

Lawyers occasionally do, it is true.

Evidently the professions differ materially in their methods of securing their share in the distribution of the world's wealth, and as it now stands engineers are worse handicapped than plumbers. In all earnestness, therefore,

I ask why is the time not ripe for the formation of a Surveyors' League, if you please so to call it; and having organized, strike for a "living salary." As to what a living wage would be, it is evident that everything goes by comparison. Judged by what hod-carriers and masons receive—and the price of meat, I should be in favor of a scale about as follows:

Bellman	$8	for 8	hrs.
Leveler	11	" "	"
Computer	12	" "	"
Draftsman	13	" "	"
Transitman	15	" "	"

Overtime, double pay.

Yours truly, G. P. H.

New York City, Sept. 11, 1902.

Before one assents to the proposition that the engineering profession should be reorganized in imitation of the labor unions, it would be well to inquire concerning the methods by which hod-carriers and other union organizations are able to obtain such very high wages. We doubt if our correspondent himself would be prepared to urge the adoption of such methods by engineers.

It is undoubtedly true that those engaged in intellectual pursuits—teachers, preachers, engineers, literary men—often receive less than many labor union workers employed in manual labor. Yet the former have certain compensations, not the least of which is the possible opportunity to enter more lucrative work, that comes to a considerable proportion of engineers at some time or other.—Ed.)

Notes and Queries.

Mr. B. Judson states that in excavating on the east side of Pearl, near Beaver St., New York city, in May, 1901, about 220 ft. of wooden pipe was taken out of the ground. He desires to secure information in regard to the date at which the same water mains were laid.

A correspondent asks for the dimensions of port openings in the 6,000-HP. rolling-mill engine built by the Filer & Stowell Co., of Milwaukee, Wis., and illustrated in our issue of Aug. 28. The engine has cylinders 44 and 82 ins. in diameter and 60 ins. stroke. The areas of port openings are as follows: Steam ports, 131 sq. ins. for the high-pressure and 406 sq. ins. for the low-pressure cylinders; exhaust ports, 177 sq. ins. for the high-pressure and 572 sq. ins. for the low-pressure cylinder.

TELEPHONE TUNNELS AND AUTOMATIC TELEPHONE EXCHANGE SYSTEM AT CHICAGO.

The tunnels now being built at Chicago to form the conduits for the Illinois Telephone & Telegraph Co. have been described and illustrated in our issues of May 2, 1901, and July 17, 1902, and at the meeting of the Western Society of Engineers on Sept. 17, two interesting papers were read dealing with the tunnel conduit construction and the automatic telephone exchange system which this company will install. From these papers we have been permitted to take in advance the additional information which is given below.*

The first paper was read by Mr. George W. Jackson, Chief Engineer and General Manager of the Illinois Telephone Construction Co., which is building the tunnels, the work being done by day labor and not by contract. At the beginning of its enterprise the telephone company realized that nearly all telephone companies had had trouble from insufficient capacity of the conduits, and failure to provide for the growth of business, and it therefore decided upon the tunnel system, as giving much greater capacity than the ordinary style of conduit, and more particularly as there was not room near the surface of the streets of the business district to accommodate another line of ordinary conduits. Under the circumstances the tunnel system was also considered to be the speediest and most economical in construction. In preparing to start the work it was found that no accurate map of the streets was to be had, and it therefore became necessary to make a survey of the city. This work was done between the hours of 10 p. m. and 5 a. m., and was under the charge of Mr. Alfred Slade. As a result of this survey, some 38 tunnel connections have been made with little or no error in line. It was at first proposed to build inclined manholes to the streets, through which to pass the cables, as is done for the surface conduits. The City Engineer, however, would not permit this to be done, on the ground that such manholes would interfere with a subway or underground railway, the construction of which is considered inevitable at some future time. The company, therefore, abandoned all manholes, and arranged to build a large shaft at its warehouse, with elevators to take down the cable reels, the trunk tunnels being made large enough to accommodate an electric car with a reel mounted upon it. The City Engineer required that the crown of the large-sized tunnels should be at least 24 ft. 6 ins. below the surface.

The trunk tunnels are 12¾ × 14 ft., and the smaller tunnels 7½ × 6 ft., with single or double tracks of 14 ins. gage. At the present time 12 miles of tunnel have been completed, forming a network under the principal streets of the business district. The entire system will comprise about 60 miles, extending north to Fullerton Ave., south to 71st St., and west to Kedzie Ave. Work is in progress at 14 headings, about 850 tunnel men being employed, and working in three eight-hour shifts. The two shifts of miners average a progress of 21 ft. per day at each heading. About 600 other men are employed in hauling the excavated material away from the shaft and hauling material for the concrete to the shafts. The material at this depth is a stiff, dry clay, and no water has been encountered. The clay is excavated mainly by draw knives, and loaded into small cars 20 × 48 ins. inside, which can be easily handled. These cars are run to the shafts and raised to shaft houses built on the curb line of the street or within buildings. There are at present eight of these shafts. The clay is dumped into wagons and hauled away. At one disposal point on the lake front, where the clay is used for filling on land, a large stiff-leg derrick has been erected. This first removes the side boards of the wagons and then raises the wagon bed and its load, swings it round to the desired position and dumps it. The wagon bed is then set back on the axles and the side boards replaced. This method is very quick and economical, as the clay is so stiff and hard that it would be difficult to dump it in the ordinary way. At the shaft at Market St. and the river, the cars are hauled up an incline to the surface by a continuous chain having arms which engage the axles. The cars are run out on a platform along the bank, from which hinged platforms or aprons are lowered by tackle attached to gallows frames, the aprons extending over the dump scows, into which the clay is discharged.

The pneumatic system of tunneling has been adopted as a precaution against emergencies and against the danger incident to possible stoppage of work by labor troubles. Air pressure is not required to sustain the face and no shields are used. The air pressure is about 5 to 7 lbs., and the air locks are made long enough to take in 8 to 10 cars. There is an air lock at the foot of each tunnel. For building the tunnel lining steel ribs are used, 3 ft. apart, with plank lagging. For the large tunnels, the ribs are of 5-in. steel channels, and the lagging consists of plates of No. 12 steel. The concrete lining is rammed between the lagging and the sides of the excavation in 6-in. layers. The top or key section is built in 3-ft. lengths after the bottom, walls and crown have been completed. The trunk tunnels have a 21-in. bottom and 18-in. walls, while the smaller tunnels have a 13-in. bottom and 10-in. walls. A coating of 1 to 1 cement mortar is applied to the face of old work before new concrete is placed against it. The concrete is composed of 1 part Portland cement to 5 parts of gravel or of stone (with screenings included); for the intersections, however, the proportions are 1 to 4. It is all mixed by machinery, and distributed by cars. The intersections involve special work, as many of these have four diagonal tunnels connecting the two intersecting tunnels, the plan at intersections being a cross connecting the corners of a square. The sides of this square are curved. At the intersections the concrete in reinforced by steel rib and roof beams. No complaints have been made as to the work, and no accidents have occurred either to the work or to the men. The work is being done by day labor under the direction of Mr. Jackson.

The second paper, by Mr. J. F. Crook and Mr A. E. Keith, described the telephone system to be used. This will be the Strowger automatic telephone exchange system, and will be installed by the Automatic Electric Co., of Chicago, which has acquired the rights of the Strowger system for the United States. By this system each subscriber can connect with and call up any other subscriber. The automatic telephone consists of the usual transmitter, receiver, bells, battery and induction coil, with the addition of the "selector" calling apparatus. On the front of the box is a disk having near the circumference ten finger holes, numbered 1 to 0. To call the number 254, for instance, the subscriber puts his finger in hole No. 2 and revolves the dial till it strikes a stop; on releasing it the dial returns to its normal position. The same operation is repeated for 5 and 4. The first operation connects the telephone with the trunk line of the "200" group of switches at the exchange (that is, the trunk line serving telephones 200 to 299). The succeeding operations connects with switches Nos. 5 and 4 in this group. The pressure of a button then rings the bell on the telephone of subscriber No. 254, and if this telephone is already in use the caller is notified by a buzzing sound in the receiver. This not only eliminates the frequent delays in getting connections made at a manual exchange, but also ensures much greater privacy, as no subscriber or central station operator can cut in and listen to the conversation.

This system eliminates many of the troubles due to the exchange in the ordinary system, and it is much more economical both in operation and maintenance. In busy manual exchanges the number of operators must be increased during the busiest hours of the day. In an active exchange of 2,000 lines about 50 girls or operators would be required, and in a New York downtown exchange one operator is required for every ten subscribers. With the automatic exchange, only two attendants are required, no matter how many subscribers are accommodated or how many calls are made, as the attendants have simply to keep the apparatus cleaned, oiled and in proper condition.

This system is now in use at New Bedford and Fall River, Mass., the latter having now 900 telephones in use, while each of these plants is designed for an ultimate capacity of 10,000 lines. Plants with capacity for 19,000 lines are also being installed at Dayton and Columbus, O., beginning with 6,000 and 7,000 stations, respectively. The system has also been in service for over a year at Berlin, Germany, where the exchange has 400 stations, and this plant has proved so satisfactory that it has been taken over by the government. The company proposes to provide capacity for 100,000 subscribers in Chicago, and it is stated that some 25,000 switches will soon be ready for operation in the business district of the city.

*The papers will be published in full in the October number of the "Journal" of the Western Society of Engineers; Secretary, J. H. Warder, 1736 Monadnock Block, Chicago.

MANUFACTURERS' MATERIALS last year formed nearly one-half of the total importations, constituting the most remarkable feature of the year's foreign commerce. The U. S. Bureau of Statistics says that, combining crude and wholly or partially manufactured material, the total value of these imports equalled in 1902 $418,776,681, as compared with $217,571,551 in 1881, and in 1892 this import amounted to $278,315,966. The money does not indicate, in all cases, the real growth of imports, as volume has increased with a fall in price. Thus, while the value of raw silk imported in 1902 is only 3½ times as much as in 1880, the quantity is more than five times as much. In other lines the gain in quantity between 1880 and 1902 is as follows: India rubber, less than 17,000,000 lbs. to over 50,000,000 lbs.; fibers, from 118,024 tons to 305,727 tons; tin, from 32,000,000 lbs. to 79,000,000 lbs.; cotton, including waste, from 3,500,000 lbs. to 113,000,000 lbs.

POLAR EXPEDITIONS are reporting. Lieut. R. E. Peary is nearly home, after a three years' stay in the Polar regions. In May, 1900, he reached the northern extremity of Greenland, rounded it, and established beyond a doubt that Greenland is an island and is the most northerly known land in the world. Lieut. Peary also traveled over 2,400 miles on the inland ice-cap; made two trips across Grinnell Land; determined the origin of the so-called paleo-crystic ice, or floe-bergs; and in April he started north over the Polar Sea, and after much difficulty he reached 84° 17′ North Latitude, the highest yet attained in the Western Hemisphere. He has added very much to the geography of this region. Mr. E. V. Baldwin,

of the Baldwin-Zeigler Arctic Expedition, has reached London. His trip to Franz Joseph Land has added practically nothing to the general sum of knowledge. He scouts the idea of an open Polar Sea and agrees with Lieut. Peary that the only practical way of reaching the Pole is by sledging. Capt. Otto Sverdrup, in the "Fram," spent the winter of 1898-9 on Ellesmere Land, and passed the summer and next winter at practically the same place. In August, 1900, he traversed Jones Sound and Cardigan Strait, and wintered at 76° 48′ N. L. and 89° W. L. The "Fram" was held in the ice until Aug. 8 last, when she managed to break away, and Sverdrup left Cape Farewell for home on Aug. 28. The sum of his voyage is the exploration of the south and west coasts of Ellesmere Land, and some unknown regions west of that.

IRRIGATION IN OHIO, or one section of that state, was recommended by the Ohio Water Delivery & Irrigation Society at a meeting recently held at Yellow Springs. After reciting in some detail the variability of the rainfall in that state and section, the resolutions adopted read as follows:

Resolved, That we recommend the impounding of the winter and flood waters of the Little Miami Valley for summer uses, especially for the irrigation of crops at times when they most need it, and for delivery of water by pipe lines to farmers for domestic and stock watering purposes. Every farmer should impound as much water upon his farm as possible for his own private use and to conserve the moisture of the general region, as stored moisture, presenting cool surfaces, will increase the annual precipitation, especially the summer precipitation, which is most needed.

Resolved, That this society shall appoint at this meeting a committee whose duty it shall be to survey the Little Miami Valley from Yellow Springs to Cincinnati, with a view to locating water sites for pumping stations and impounding reservoirs for the service of farms and villages; this committee shall give out, free of charge, information as fast as obtained to farmers and villagers as the survey proceeds, and make reports of progress and a final report to this society.

Resolved, That farmers and villagers are urged to develop these water privileges themselves, uniting in a system extending throughout the entire valley; that we invite water engineers and irrigation experts to visit this valley and suggest the most improved method of elevating, impounding and distributing water.

Mr. John Bryan is president of the association and a member of the committee on survey, but we are unable to give his address.

THE VALUE OF SHOP WORK for engineering students is gradually coming to be appreciated in Germany. The Royal Technical College at Charlottenburg will hereafter require, as condition precedent to admission to the final examinations, at least one year of practical machine-shop work, in the case of mechanical and electrical engineering students, and the same amount of practical work in a shipyard in case of students of shipbuilding. Similar regulations will probably soon be promulgated for the Royal Technical Colleges of Hanover and Aachen. This is the result of a strong agitation in this direction on the part of the "Verein Deutscher Ingenieure," and this society contemplates continuing the movement to the end that all technical colleges in Germany may reach a similar position.

PROGRESS IN STEEL-WORKS PRACTICE IN GERMANY SINCE 1880.*

By R. M. Daelen, Düsseldorf.

Since the last occasion on which the Iron and Steel Institute visited Germany in the year 1880, a notable development has taken place in the production of steel in that country. In 1880 the annual production of wrought iron in Germany amounted to 1,270,000 tons. In the year 1901 the former figure had, however, fallen to 900,000 tons, and the production of mild steel for that year rose to over 6,000,000 tons, the classifications being as follows:

	Acid process, tons.	Basic process, tons.	Total mild steel, tons.
I. Ingot metal:			
(a) Produced in the converter.....	299,816	3,975,070	4,274,886
(b) Produced in the open-hearth.....	125,590	1,886,536	2,012,126
II. Steel castings	39,634	67,576	107,210
Total production...	465,040	5,929,182	6,394,222

The above represents the output of 103 steel works in 1901.

THE BASIC BESSEMER PROCESS.

The invention of Thomas and Gilchrist in 1878, by which the difficulty of providing a durable basic lining for converters was solved, has largely contributed to this development since. Owing to the possession of an abundance of ores rich in phosphorus, Germany was able to profit by this invention in a greater measure than the other iron-producing countries. A few years later, after many attempts, in which German works bore a large share, a durable basic lining was also found for open-hearth furnaces. The following tabular statement shows the development of the two processes:

Germany and Luxemburg.	Converters. Acid No.	Acid Capacity tons.	Basic No.	Basic Capacity tons.	Open-hearth furnaces. Acid No.	Acid Capacity tons.	Basic No.	Basic Capacity tons.
1880....	46	3-8	4	3-6	12	3-10	0	0
1900....	26	6-8	91	6-21	23	3-18	219	4-30

Acid-lined converters are now only worked at one or two German works, which in other respects have not modernized their plant, while at those works where the basic process is practiced every modern improvement of importance has been adopted, such as the direct tapping of the liquid pig iron from the blast furance into the converter, the capacity of which has been increased to 20 tons, the requisite independence of the blast furnace and the steel works being in the meantime assured by the introduction of the pig-iron mixer. By these means the number of charges in the 24 hours has reached as much as 72. The employment of the mixer concurrently for the purpose of desulphurizing the molten metal, was first attempted at the Hoerde Works and has resulted in securing a further advantage from its use, so that the low working expenses are fully compensated for, and the only attendant disadvantage consists of the unavoidable loss of heat by the cooling of the metal.

As is well known, by far the largest proportion of the mild steel produced in Germany is made in the basic Bessemer converter, and these conditions are likely to obtain for a long time to come, on account of the nature and quality of the ores available. The somewhat stringent requirements of the consumers as regards the quality of the finished product are also best met by this method of production. A difficulty is now, however, beginning to be felt in some districts in obtaining pig iron with the necessary percentage of phosphorus, which should amount to about 2%, and in consequence the numerous efforts to discover a process in which a lower percentage would suffice appear to be fully justified. Since with the above proportion, which cannot often be exceeded, no considerable evolution of heat occurs in the converter, the remelting of waste pieces is possible in a very much less degree than is the case in acid working. Consequently a greater number of open-hearth furnaces is necessary for dealing with the waste and scrap. These are generally of the basic system, lined with crushed dolomite, and their capacity is about 15 to 20 tons. A capacity of 30 tons is rarely exceeded, and there are in existence only very few furnaces of 50 tons.

OPEN-HEARTH FURNACE PRACTICE.

In the west of Germany the usual practice is to melt a charge consisting of 25% pig iron and 75% small scrap, six heats per 24 hours being obtained from a 15-ton furnace, while from a 25-ton furnace not much more than four are possible in the same time. From this it would appear that, since the output remains about the same, no particular advantage is gained by the adoption of larger furnaces, unless it is a question of producing very large and heavy ingots or castings. The initial outlay in constructing a large number of small furnaces is not so great as that required for the construction of a smaller number of large furnaces, and the consumption of fuel, amounting in the former case to 270 kg. per ton of steel, is not in any way reduced by using larger furnaces. On the other hand, the number of charges per day falls to 2½ when the proportion of pig iron is increased to 80%, a practice often followed in the east of Germany, and in that region, therefore, furnaces of larger capacity can be more suitably employed. In such instances the tilting furnace would be practicable, of which there is at present no example at work in Germany. It can, however, scarcely be anticipated that in those works where the open-hearth furnaces are principally used for the melting of scrap, a sweeping change in the existing system of furnaces is contemplated and since the majority follow this practice and since the scrap, too, is cheaper than pig iron, it is clear that the various attempts to expedite the treatment of liquid pig iron in the open hearth, and thus to increase the production, are not likely to find favor in Germany. There are, besides, further reasons for adhering to this system, which should be taken into account in considering the adoption of any improvements which aim at increasing the capacity of the steel works, without effecting a considerable saving in the cost of production. These consist in the recent remarkable extensions of existing steel works in general and the construction of many entirely new steel works on a large scale, such as have been built in the last few years in West Germany and Luxemburg, coincident with which there occurred a temporary decline in the demand for iron and steel products in large quantities. The causes operating to produce this decline are chiefly due to the fact that the network of railways in Germany is now for the most part complete, and that the general activity in the building trades slackened on completion of alterations and new works in many towns. And for the present no new enterprise on a large scale is in contemplation.

GERMAN IRON TRADE CONDITIONS.

There is, however, no cause to apprehend a general and lasting depression in the iron-making industry, for it is a matter of common knowledge that periods of development at the furious rate latterly experienced both in the production and consumption of iron are invariably succeeded by such an interval of quietness, and naturally the revival of business proceeds at a slower pace than that at which the preceding decline took place. That such a revival has now set in is evident from the increased activity of the iron works and the improvement in the selling prices, which latter may at the present time be regarded as generally remunerative, although in consequence of the attitude of the syndicates the raw material is relatively more expensive than the half or completely finished products of the rolling mills. In other respects the determined endeavor of German technical industry to discover new markets for iron products is manifested by the buildings of colossal proportions at the Düsseldorf Exhibition and their contents. A comparison of them with the buildings at the Exhibition of 1880, or even with those of the Paris Exhibitions of 1889 and 1900, shows that structures of iron pure and simple have to some extent given way to a combination of iron work with stone and concrete. This is, however, by no means to be regarded as a retrograde step in the application of iron to such purposes, but is indicative of the endeavor to solve the important problem of finding adequate means of protecting the iron work of buildings from becoming heated by an outbreak of fire within. Iron alone does not confer safety against the effects of fire. The necessary steps towards the achievement of this have already been initiated, and the 50 years of successful endeavor in extending the use of iron on the part of German technical science are a sufficient guarantee that a satisfactory solution of the question will be found. The compiling of the book of standard sections and the publication of standard designs for iron structural work furnish an eloquent proof of the ability to deal successfully with the matter.

APPLIANCES IN STEEL WORKS.

The above is a brief review of the general situation of the German iron industry. Returning now to the methods in use for the further treatment of steel, it will be found that the older-established works have for the most part retained the well-known system of casting ingots, consisting of a hot-metal ladle carried either on a slewing or traveling crane, and successively placed above the stationary ingot molds. On the other hand, only a few of the more modern works have adopted the reverse method of drawing the ingot molds along beneath a stationary ladle, combined with which process is also the forcing out of the ingots from their molds by mechanical means.

The latter method does not permit of filling several molds at once by bottom pouring, and its adoption has extended according to the ability to roll rough ingots at one heat into finished products such as wire, rods, small sections and plates, which formerly had to be reheated after one rolling. By this means in many works the blooming rolls are dispensed with, an arrangement, however, which is only profitable where the daily production is a perfectly regular one, such as is usual in the very large basic Bessemer steel works.

It is the special aim in these works to roll down the ingot at the original heat, that is, by the use of the Gjers non-fired soaking pits. The Gutehoffnungshütte first developed this system, and at these works the ingots after passing through the blooming mill, are rolled without any reheating into sections, rails, and sleepers in a three-high mill. The results were so successful that other works have now followed the same plan. The steel manufactured by the basic process can be removed from the molds, and plunged in the plain soaking pits sooner than that blown in acid-lined converters, a fact which tells in favor of the system. It is also necessary to provide a means of transferring the ingot from the blooming rolls to the finishing rolls as rapidly as possible. When this cannot be done, as in the case of works which have no blooming mill, soaking pits, fired on the Siemens regenerative system, are employed, though the disadvantage then arises, that the entire charge is heated at one time, and that the subsequent introduction of cold ingots has the undesirable effect of cooling those still remaining in the pits. To obviate this difficulty many works employ in connection with the soaking pits the rotary furnace of Helmholtz, of Ruhrort, in which the ingots are carried forward to meet the flames. But this apparatus necessitates too much hand labor, besides being productive of considerable waste of metal, and on this account, since the prevailing requirement is a uniform method which ensures the heating of cold ingots and the preservation of heat in the hot ingots, the American continuous reheating furnace with pushing gear has latterly been introduced in several places, the results of which are more satisfactory.

The manufacture from mild steel of tubes and hollow bodies of every variety and size, both welded and seamless, has experienced a specially noteworthy development, of which plentiful proof is furnished by the display in the exhibition. The welding of hollow bodies is performed partly by heating in coke fires, partly by the use of the water-gas flame. This latter medium is particularly suitable for welding, though in other respects water gas has not yet found extensive application in iron works, since the Siemens producer gas, containing 40% or more available fuel, still meets all requirements.

To keep pace with the production of steel works, the daily capacity of the machines and appliances for working up the material, and of the rolling mills in especial, has been increased. Wherever possible, every appliance

*A paper read at the annual convention of the Iron & Steel Institute, held at Düsseldorf, Germany.

which is the outcome of the ceaseless progress of modern invention has been brought into play to lower the cost of production. To enter fully into the whole of such details would occupy too much time, and the author therefore limits himself to the following points: The introduction of the blooming mill for small and large ingots, and the development of the two-high and three-high trains as finishing mills, with the continued improvement in the methods of counter balancing; and the use of valve gears of precision for controlling the rolling-mill engines when working at the highest speed of piston and maximum revolutions per minute. After many trials with valves and slides, the form of valve which has found most favor is the cylindrical with a motion in the direction of the axis, the Corliss valve also, in some cases, having been adopted. Very considerable economies have also been effected by the use of efficient condensers, particularly of central installations of these and recently by the employment of superheated steam. Quite recently it has been attempted experimentally, to drive rolling

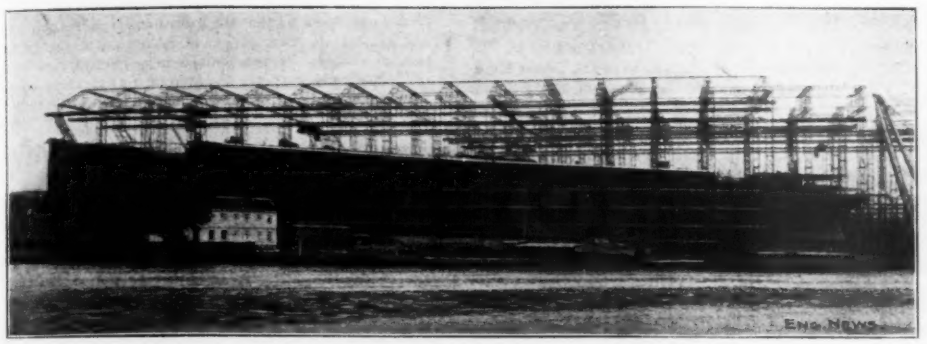


FIG. 1. THE HULL OF THE "KAISER WILHELM II." BEFORE LAUNCHING.

mills direct by means of gas engines, thus opening up a possible further application for these as prime movers in the event of success. Their use would, however, be conditional upon the use of a flywheel in connection with the system of driving the mills, for if no flywheel is required the two-crank or three-crank engine is without doubt a preferable arrangement, provided that the consumption of steam and other working expenses are not greater than those of engines with flywheels. With the newer types of the latter this question appears, however, to be decided, as may be learnt from the following particulars which have been furnished by various manufacturers. It should, however, be borne in mind that the consumption of fuel is not the only criterion in the selection of a suitable motor for a rolling mill, but the capacity of the latter to fulfil the working conditions is a consideration of the greatest importance. Although devices have been introduced by which the reversing of the rolls can be effected without experiencing a tremendous shock, and though the risk of a breakdown is still further reduced by the use of cast-steel spur gearing, yet the variation of speed in rolling down ingots, which is only attainable in the flywheelless engine, is too serious a consideration to allow the general adoption of non-reversing engines with flywheels.

The deciding of the issue between the reversing and non-reversing engine will exercise an important influence on the question of the adoption of the two-high or three-high rolling mill in modern work, and the chief arguments for or against either arrangement may therefore be briefly outlined. For rolls of 600 mm. (2 ft.) diameter, the three-high system driven by a flywheel engine is likely to find favor; a four-high mill with rolls up to 400 mm. (16 ins.) diameters, may be found preferable where a very perfect rolling of special sections is essential, because the balancing and the exact adjustment of the roll bearings is easier as compared with the three-high mill. The three-high system is, however, still used with diameters up to 900 mm. (3 ft.) where the reversing two-high would, in many cases, be more advantageous, if the question of cost were also in favor of the latter. The Lauth three-high mill, for instance, could serve for the first rolling of thin plates, by driving the whole train with a flywheel engine; on the other hand, for thick plates the method of driving without a flywheel would certainly be best suited. The same rule would hold good so long as the rolls exceed 600 mm. (2 ft.) diameter, and so long as the two-high system does not involve a considerable increase in the number of stands. The extra cost of these would, however, be compensated for in great part by dispensing with the lifting tables, and by the consequent simplifying of the live-roller driving gear, and of the upsetting gear. Less hand labor would also be required.

With regard to the number of rolls to be provided for a rod and bar-iron mill, it may be mentioned that as the result of improvements in the balancing a considerable reduction in the length and number of rolls has already been effected, and there is a prospect of a further advance in this direction. In practice the two-high mill gives a greater daily output, and suffers less from abrasion than a three-high mill, owing to the greater speed of the rolls in the latter, and because the middle roll has twice the work of the other two, being used at every pass. The changing of the rolls is also easier with a two-high than with a three-high mill. In this connection it is advisable, when rolling sections, to have two finishing trains to one blooming mill in order to avoid stoppages, and it is then a great advantage to be able to lift the entire stands with their rolls on a traveling crane, as is now done at the new works of the Rheinische Stahlwerke at Ruhrort.

Further important improvements have also been effected by making the complete stands with bearing blocks and rolls of cast steel. The latter are also often made of forged steel.

The arrangement of the cogging rolls as compared with that of older plants has been improved by placing the stand on the long bed plate with machined V-shaped guides, and attaching this latter securely to the engine bed plate. The stand is also closed underneath to form a trough, so that the lower cogging roll always runs in oil and carries this up with it. Further, the cogging rolls are made hollow to receive the wobbler end, by which means the number of sockets, and consequently the length of the trains, are reduced.

The use of electric motors for driving rolling mills is at present very limited, and will probably only be adopted in cases where the electricity is generated more cheaply than is possible by steam power. It is, however, now very largely used for driving the auxiliary machinery about the mills, and it is generally regarded as certain that in modern works it will entirely supersede the low-pressure hydraulic machinery which formerly was in common use. Still, it must be admitted that the same precision of movement in cranes and hoisting gear is certainly not attainable by electric means, and for this reason many practical engineers of iron works still have a preference for low-pressure hydraulic power, especially as the machinery which gives it effect is constantly being improved.

For the production and application of high-pressure water power the intensifier actuated by steam pressure has proved a lasting success.

In general it may be observed that the German steel works and rolling mills are compelled to bestow strict attention on their plant and their practice in order to meet the requirements of their market—these are of so diverse a nature, and orders for one quality or form of product are by no means of the same magnitude here as is often the case in the same industry in other countries. In arranging the buildings and machinery, the chief aim to keep in view is accordingly not only a large daily output and the saving of labor, but it consists rather in devising how to do work at remunerative rates even with apparatus and machines of medium productive capacity, and with frequent changes in the kind of material supplied. If on this account the German works are less imposing as compared with modern installations abroad, we can console ourselves with the reflection that circumstances must be adapted to meet conditions, and that limits can be set to all competition, however much this may be feared.

THE "KAISER WILHELM II.," THE LONGEST STEAMSHIP EVER CONSTRUCTED.

A new steamship for the North German Lloyd's transatlantic service, the "Kaiser Wilhelm.," was launched on Aug. 12 at the yard of the Vulcan Machine Co., at Bredow, near Stettin, Germany. This vessel is longer than any other ever built, though not the largest in point of displacement. It is also expected to surpass any of the great transatlantic liners in speed. The colossal size and perfect equipment of this great floating hotel that moves through the water with the speed of a railway train is by itself sufficiently interesting; but in addition to this the structure contains a power plant of 40,000 HP., or nearly half as large as the greatest of the recently-built tremendous power plants for furnishing electric current in New York city, whose unprecedented concentration of power has been the wonder of the world.

Some figures in regard to this vessel may, therefore, be worth noting. We are indebted for our data to the "Zeitschrift des Vereins Deutscher Ingenieure," and from the same source have selected several views for reproduction. Of these views, Fig. 1 shows the vessel under construction, lying broadside to the beholder. Fig. 2 gives an idea of the framing of the ship, the portion in the foreground being well toward the stern. A view quite at the stern is Fig. 3; the sideward extensions of the frame will carry the screwshafts, and the ship's side-plating will entirely surround these extensions. A part of the stern frame with its lugs for the rudder stem also shows clearly. Fig. 4 is from a photograph of the main engines of one side, the vessel having twin screws. The figures of the men in the picture serve to give a conception of the size of the engines; the two units shown represent 20,000 HP.

The principal dimensions of the "Kaiser Wilhelm II." are:

Length on deck, ft.	706.3
Breadth, ft.	72.0
Depth to spar deck, ft.	52.5
Displacement, fully loaded, tons	28,000
Weight when launched, tons	12,500
Engines, I. HP.	40,000

Comparing this vessel with the largest recent ocean steamers, (1) the "Kaiser Wilhelm der Grosse" (North-German Lloyd, 1897), (2) the "Deutschland" (Hamburg-American Line, 1900), and (3) the "Kronprinz Wilhelm" (North-German Lloyd, 1901), all three of which were also built by the Vulcan Co., also with (4) the "Oceanic" and (5) the "Celtic," both of the White Star Line, we have for these others the following figures:

	1.	2.	3.	4.	5.
Length, ft.	648.0	684.0	663.3	704	700
Breadth, ft.	66.0	67.0	66.0	68	75
Displacement, tons	...	...	...	28,500	37,700
Engines, I. HP.	28,000	37,500	36,000	...	...

The first three of these vessels have made records of average speed in transatlantic voyages, of 23 to 23.5 knots, and as above noted, the present steamship is expected to improve on this figure.

The "Kaiser Wilhelm II.," constructed entirely

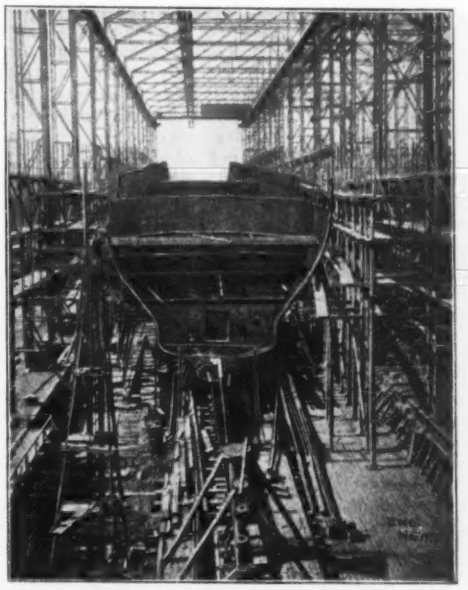


Fig. 2. View of the "Kaiser Wilhelm II." During Construction.

of steel framing, has a double bottom throughout its length, the space between divided into 26 water-tight compartments. There will be 16 transverse bulkheads extending up to the upper deck, and a longitudinal bulkhead between the two engine rooms. This will give 19 water-tight compartments, and the arrangement is such that the vessel will be safe even though two adjacent compartments should fill with water. Each compartment which is devoted in whole or part to the use of passengers, has a separate stairway to the upper deck. Thus, at night, or in a fog, all bulkhead doors may be kept closed. There are 52 such doors, and 24 of this number are fitted with

the Doerr electric closing mechanism, and can be closed from the pilot house. An indicator board is fitted in the chart room, which shows to the captain at a glance which of the water-tight bulkhead doors are closed.

The vessel will have five full decks, the upper one serving as lower promenade deck, and two partial decks above this. There will be accommodations for 775 first-class, 343 second-class and 770 third-class passengers. The ship's com-

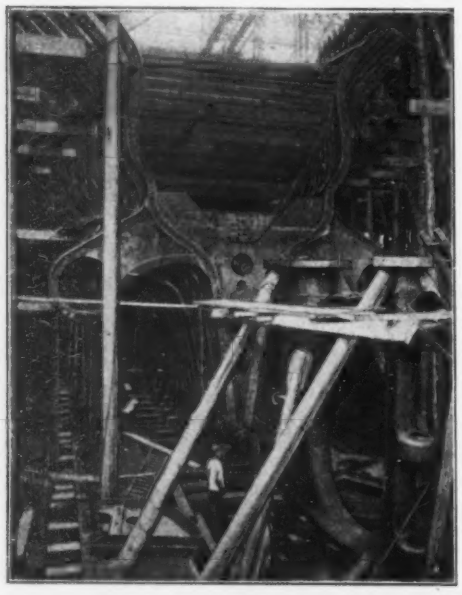


Fig. 3. Framing at Stern of the "Kaiser Wilhelm II."

plement will include about 600 men; among this number are 48 engineers and oilers, 229 firemen and coal handlers, 231 stewards, cooks, waiters, etc., and 45 sailors. Steam heating, electric lighting, and a complete ventilating system are provided. There will be a great abundance of electrical fittings, ranging all the way from a fire-alarm system and engine signals down to curling-iron heaters in all first and second-class rooms.

The main engines of the "Kaiser Wilhelm II." are four in number, two in tandem on each side. Each of the four engines is a triple-expansion, three-crank, four-cylinder machine, with the reciprocating parts balanced after Schlick's method. The aggregate power of these engines is about 40,000 I. HP. The crank shafts and thrust shafts are 25 ins. in diameter and are made of nickel steel.. The screw shafts are about half an inch thicker and are made of crucible steel; the intermediate shaft sections are of open-hearth steel. Each of the two screw shafts carries a bronze screw, 22.8 ft. in diameter, with four flukes.

Steam is furnished at 206 lbs. pressure by 12 double boilers and 7 single boilers, which aggregate over 100,000 sq. ft. of heating surface and about 3,100 sq. ft. of grate surface. The boilers, arranged in four groups, are surrounded by the coal bunkers, which have a capacity of about 6,000 tons of coal. There are four smokestacks, one to each group of boilers; each stack is 16½ ft. in diameter and extends to a height of about 130 ft. above the keel.

The electric generating plant comprises five direct-current dynamos, each of 80 KW. capacity, furnishing current at 100 volts pressure. There is a notable absence of electrically-driven auxiliaries, steam power being used throughout. This auxiliary machinery includes, among other items, six steam winches for freight handling, four boat hoists, and eight ventilating fans. Excluding the four main engines there are 75 steam engines distributed over various parts of the ship.

In accordance with the requirements of the German navy department, the "Kaiser Wilhelm II." is so constructed and fitted that it can in time of war be converted into an auxiliary cruiser. With this object in view the rudder and steering-gear are located entirely below water-level, and space and support is provided for a suitable armament of guns.

SSURE WATER SUPPLY SYSTEM FOR FIRE PROTECTION IN CHICAGO.

During the past summer the City Council of Chicago directed the Mayor to appoint a special commission to investigate the subject of establishing a high-pressure water supply system for the fire protection of the business and manufacturing districts of the city. This Commission was appointed some weeks ago by the Mayor, Mr. C. H. Harrison, and has held a few meetings, but it will be some time before any report is made. The commission is composed of three aldermen, the Commissioner of Public Works, the Chief of the Fire Department and ten representative business men. This Commission has appointed an Advisory Board of Experts, composed of the following mem s: Wm. C. Robinson, A. W. Hardy, Albert Blauve Robert Jardine, F. W. Southard, and S. H. Lockett, all insurance engineers; Clarence S. Pellet, underwriter adviser; Wm. H. Musham, Chief of the Fire Department; F. W. Blocki, Commissioner of Public Works; John Ericson, City Engineer, and E. B. Ellicott, City Electrician. The Secretary of both the Commission and the Advisory Committee is Mr. H. B. Seely, 218 La Salle St., Chicago. We recently applied for information as to the work of these organizations, and received a communication from Mr. Seely, which we reprint below:

The special purpose of the Commission is to make inquiry as to what extent the system of fire protection described by the Hon. Edward Atkinson can be adapted to the conditions existing in congested districts and in what manner co-operation through municipal powers can be utilized to reduce the cost of installation and operation to the individual.

We are seekng to devise a separate system of mains and pumping stations connected with street hydrants and apparatus of buildings so as to deliver water in such volume and force that steam fire engines, private pumps and private storage of water on the tops of buildings may be safely abandoned. In addition, we plan to have each building provided with direct telephone connection with the city alarm office and to substitute the alarm check valve for the water meter on all direct connections. The wires of these alarm valves would extend to the city alarm office, thus making complete automatic alarm systems of automatic sprinkler equipments. We further aim to facilitate the installation of automatic devices in those buildings adapted to their use, and to develop the installation of stand-pipes on all buildings, so as to avoid the delay and loss of power incident to the use of long lines of hose attached to hydrants.

The fighting base would be shifted from the street to the spot where the fire had ignited, and the alarm system would be relied upon to increase the percentage of fires fought during the period of incipiency. The s public and private fire protection apparatus of such would be operated by the fire department as a stationary department, substituted for the num and inadequate portable units of the present method. The fire department in such a district would be organized to make examination of plans and i of apparatus and maintain constant inspection the apparatus in working order, and to correct faults management found on premises.

It would be possible through such a system, if the achievements reported by Mr. Atkinson could be paralleled, to reduce the fire losses of District No. 1 of the fire patrol of this city from $1,500,000 per annum to $500,000 per annum. Beyond question the margin of annual fire losses which may be eliminated is more than sufficient to warrant the installation as a business undertaking. The cost of operation as an arm of the fire department should show a marked reduction in annual cost as compared with the present expenditure.

The engineering features of the system are being devised by an advisory board of experts, composed mainly of the engineers of the fire insurance organization having headquarters in Chicago. It is the intent of the Commission to embody its conclusions in general terms so that any community may use the standard as established without duplicating the labor incident to its preparation.

THE NEW YORK RAPID TRANSIT RAILWAY.

XI.

Inspection of Cement.

Approximately 1,500,000 barrels of hydraulic cement, the great bulk of which was to be Portland cement, were required for the construction of the Rapid Transit Railway. Practically all of this cement was to be used mixed with sand and crushed stone to form concrete, of which the subway structure, the tunnel linings, the elevated column foundations, many of the sewers, and various minor works were constructed. According to the engineers' preliminary estimates, 48,122 cu. yds. of concrete were required for the rapid transit railway structure. To this amount the construction of the power house and other buildings and structures by the general contractor adds considerably.

The costly and permanent character of the subway; the fact that it must withstand considerable loads, and the necessity of keeping it at all times impervious to water, made it necessary to ensure beyond reasonable doubt that the concrete, of which it was chiefly composed, should be of exceptional quality. One of the first and most important steps to this end was to make sure that the cement used in making the concrete was of a uniformly high character. To do this meant

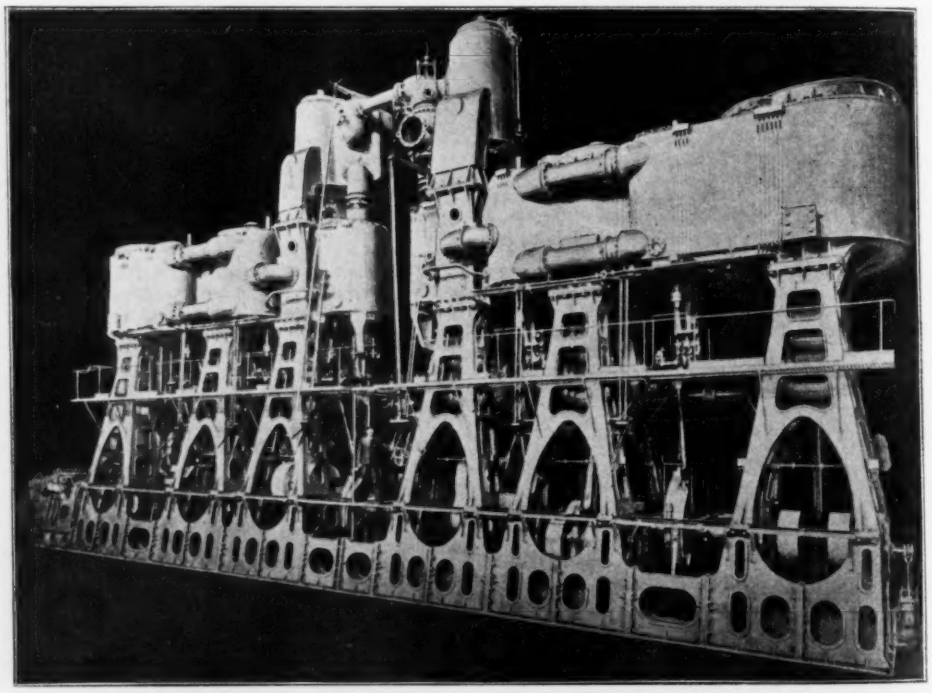


FIG. 4. MAIN ENGINE OF ONE SIDE, "KAISER WILHELM II."
Vulcan Machine Co., Bredow-Stettin, Builders.

that the specifications must be carefully and rigidly drawn, and that the tests to which the cement was submitted should be such in number and character as to make it certain that the material tested met the requirements of the specifications. To these two matters, then, namely, the specifications and the methods of inspection and tests, the engineers of the Rapid Transit Commission devoted considerable study.

SPECIFICATIONS.—The clauses of the specifications which are of chief interest were as follows:

PORTLAND CEMENT.

Fineness.—98% shall pass a No. 50 sieve, and 90% a No. 100 sieve.

Tensile Strength.—Neat, at the end of 1 day in water after hard set, 150 lbs.; at the end of 7 days, 1 day in air, 6 days in water, 400 lbs.; at the end of 28 days, 1 day in air, 27 days in water, 500 lbs.; when mixed 2 to 1 with quartz sand, at the end of 7 days, 1 day in air, 6 days in water, 200 lbs.; at the end of 28 days, 1 day in air, 27 days in water, 300 lbs.

NATURAL CEMENT.

Fineness.—95% shall pass a No. 50 sieve, and 85% a No. 100 sieve.

Tensile Strength.—At the end of 7 days, 1 day in air, 6 days in water 125 lbs.; at the end of 28 days, 1 day in air, 27 days in water, 200 lbs.; when mixed 1 to 1 with quartz sand, at the end of 7 days, 100 lbs.; at the end of 28 days, 1 day in air, 27 days in water, 150 lbs.

Chemical analyses will be made from time to time, and cement furnished must show a reasonably uniform composition. Tests for soundness will be made as follows:

Portland Cement.—Tests for checking and cracking and for color will be made by molding on plates of glass cakes of neat cement about 3 ins. in diameter, ½-in. thick in the center, and with very thin edges. One of these cakes when set perfectly hard shall be put in water and examined for distortion or cracks, and one shall be kept in air and examined for color, distortion and cracks. Another cake shall be allowed to set in steam for 24 hours and then put in boiling water for 24 hours. Another cake shall be allowed to set hard in dry air for 24 hours and then put in boiling water for 24 hours. Such cakes should at the end of the tests still adhere to the glass and show neither cracks nor distortion. A briquette, in like manner, should be allowed to set hard in dry air for 24 hours, then boiled for 24 hours, be kept for 5 days in water and show 350 lbs. tensile strength.

Natural Cement.—Pats should be made on plates of glass in the same manner as for Portland cement, and tested for cracking, distortion and color, except that the boiling test will be omitted. Tests for setting will be made in accordance with requirements of the work as fast as slow-setting cement is needed.

INSPECTION AND TESTING.—The contract for the manufacture of all cement was given to the American Cement Co., whose works are located at Egypt, Pa., and are equipped for turning out Portland cement by either the dome kiln or rotary kiln process, and also for making natural cement. This company agreed that all inspection should be done at the works, and to establish a store-house for accepted cement at Jersey City, from which daily deliveries could be made to the subway work. This plan was satisfactory to the engineers of the Rapid Transit Commission, who established a laboratory at Egypt, on the grounds of the cement company, and placed it in charge of Mr. R. Frank Walker, under the direction of Mr. William A. Aiken, M. Am. Soc. C. E., General Inspector of Material. The laboratory and its equipment were furnished to the order of Mr. Aiken by the cement company, which also gave the inspectors free access to all parts of its works, so that every part of the material used and every process of the manufacture could be watched and studied.

The cement manufactured for the rapid transit work was chiefly made by the rotary kiln process, the raw material being the Lehigh limestone from which practically all of the cements of the famous Lehigh cement district are made. The process of manufacture was that generally known as the rotary kiln dry process, in which the raw cement rock is ground to a fine powder and fed dry to rotary kilns, the resulting clinker from which is ground into cement. The cement made for the subway work was stored in separate bins, each holding about 1,500 barrels. It was held in these bins until after the 28-day tests had been made, unless rejected by earlier tests, and was then packed in bags which were sealed by the inspectors and shipped to the cement company's Jersey City store-house.

LABORATORY EQUIPMENT.—The testing laboratory was installed in a small stone building, three rooms and the cellar of which were used for the laboratory work. On the first floor there were a room containing the general office equipment and tensile testing machines, and a room for gaging and molding neat briquettes and making specific gravity, setting and fineness tests. The third room, which was located on the second floor, was used for gaging and molding sand briquettes. The cellar contained the tanks for holding the long-time test briquettes and an outside room off the first floor contained the apparatus for making boiling tests. The tensile testing machines in the main room comprised two Fairbanks machines for making 24-hour neat and all sand tests and a Riehle machine for making seven and 28-day neat tests. In the second room were installed the gaging and molding tables, racks for holding the filled molds, shelving for sample boxes, immersion tanks, damp closet, etc. Gang molds, each making nine briquettes, were employed. The smaller apparatus consisted of the usual weighted needles for determining set, Le Chatelier specific gravity glasses, gaged beakers, trowels, etc. The boiling test tank was of metal, with an immersed grating for the briquettes, and was heated by steam piped from the factory boilers. Altogether the equipment and fittings throughout were those of an engineer's laboratory for making working tests and not those of a scientific laboratory for the general investigation and study of cements, such work being done in the Department's chemical laboratory at Pittsburg.

MANIPULATION OF TESTS.—The manipulation of the cement in making tests was roughly divided into three groups of processes, first the sampling, second the gaging and molding, and third the testing. The sampling process was comparatively simple.

Ten samples were taken from each bin of cement. Each of these samples consisted generally of ten sub-samples taken over the surface of the cement as ground into the bin at approximately each foot of depth. As the average time consumed in filling a bin was 55 hours, this meant that a sample made up of ten sub-samples was completed about every five hours. Sometimes, however, a sample was made up of more than ten sub-samples, the sub-samples being often taken every two hours. In all sampling the main object was to obtain representative samples of the total mass of 1,500 barrels in each bin.

From each of the ten full samples, an equal part was taken to make an eleventh sample, called an average sample. From each full sample there was made nine neat briquettes and six sand briquettes, all designed for tensile testing. From the average sample there were made 36 briquettes to be used for making tensile, boiling and long-time tests; it also furnished material for the pats for determining soundness, a pat for testing set, and powder for specific gravity test.

The gaging of the cement was done entirely by hand, the powder being placed on a stone slab, water added, and the mixing done with a trowel. Generally about 21% of water was used for gaging, but the object was rather to secure a certain consistency of paste than to maintain a set proportion of gaging water. When the gaging was completed the molds were filled by pressing the paste into them with the fingers and a trowel. The pats for setting and soundness tests were molded in a similar fashion by hand. In molding the sand briquettes, a few hammer blows were used to compress the mortar into the briquette mold, but otherwise the manipulation was the same as for neat briquettes.

As each set of eleven samples was gaged and molded the operator filled in the blank form shown by Fig. 54, with the data called for by the several headings, all of which explain themselves, except those of the last two columns. In these columns were set down the exact time of completing the molding. Generally also there was added in writing a note describing the weather, whether fair, rainy or otherwise, and giving the percentage of humidity in the atmosphere.

Upon completion of the molding, the briquettes and pats were allowed to set and harden for the periods of time and under the conditions stipulated in the specifications. The tensile tests were made at the end of one, seven, and twenty-eight days, as follows: Three neat briquettes were broken at the end of 24 hours, three neat and three sand briquettes were broken at the end of seven days, and three neat and three sand at the end of 28 days, for all samples including the average sample. Fineness, specific gravity and setting tests were made at the time of the molding and soundness tests at the periods named in the specifications. At periods of 3 and 6 months and of one, two and three years briquettes from the average sample are to be broken. As already stated, the cement was held at the works until the 28-day tensile tests had been made, unless condemned by previous tests. When all tests, including the 28-day tensile test, had been passed the cement was shipped. For shipment it was packed in bags and each bag was sealed by the inspector with a lead seal stamped with the test number and the name of the Rapid Transit Commission.

OFFICE OF

Rapid Transit Railroad Commissioners,

NEW YORK CITY.

Department of Inspection of Cement.

EGYPT, PA. _____ 190

_____ **Cement.**

Bin _____ Test No. _____

Temp. Lab. Air _____ Temp. Gaug. Water Neat _____

Temp. Lab. Air _____ Temp. Gaug. Water Sand 2 : 1 _____ %

Gaug. Water Neat _____ % Gaug. Water Sand 2 : 1 _____ %

Fineness, No. 50 Sieve _____ No. 100 Sieve _____ Init. Set _____

Final Set _____ Sp. Gr. _____

Sample No.	Date Sampled.	Time Sampled.	Sampled By.	Neat.	Sand 2 : 1
Sample Ave.					
Long Time.					

Remarks: _____

Fig. 54. Record Blank Used in Gaging and Molding Room, Rapid Transit Railway Cement Laboratory.

Complete records of the inspection and tests were kept by the laboratory. These consisted, first, of the blanks filled out during the period of gaging and molding, and shown by Fig. 54. The information from these blanks was transferred to a day-book, to which was added the results of each test and the chemical analysis. Finally, the information in the day-book was condensed in the form of averages and posted in a final record book. Reports were made weekly to the general inspector on blanks giving substantially the information contained in the day-book for transmission to the Chief Engineer.

RESULTS OF TESTS.—Only the general results of the tests made during 1900 and 1901 are available for publication. During 1900 there were made and shipped from the works 42,000 barrels of Portland and 5,000 barrels of natural cement, involving the breaking of 3,102 briquettes. During 1901 there were made and shipped 148,420 barrels of Portland and 10,920 barrels of natural cement, involving the breaking of 27,000 briquettes. Table I. shows the relative numbers of these briquettes which passed and which failed.

The average results obtained from these briquettes in tensile strength, are shown by Table II. in pounds per square inch.

TABLE I.—Showing Number of Cement Briquettes Broken During 1900 and 1901 at the Laboratory of the Rapid Transit Commission with Results of the Breaking.

			Cement—Portland. 1900.	Cement—Portland. 1901.	Cement—Natural. 1900.	Cement—Natural. 1901.
Briquettes	Neat.	No. broken	1,827	15,606	411	750
		" passed	1,733	15,560	363	750
		" failed	94	46	48	0
	Sand.	" broken	726	10,671	138	882
		" passed	698	10,654	134	882
		" failed	28	17	4	0

TABLE II.—Showing Average Tensile Strength of Briquettes Tested During 1900 and 1901 at the Laboratory of the Rapid Transit Commission.

		Neat cement.			*Sand 2, cement, 1	
Portland:	Year.	1 day.	7 days.	28 days.	7 days.	28 days.
Av'g result..	1900.	229	552	714	276	434
Av'g result..	1901.	300	645	763	380	525
Spec. re'q'ts.		150	400	500	200	300
Natural:						
Av'g result..	1900.	...	172	249	118	215
Av'g result..	1901.	...	215	322	218	350
Spec. re'q'ts.		...	125	200	100	150

*For natural cement a 1 cement 1 sand mortar was used

Besides the tensile tests of normal briquettes the specifications called for briquettes to be allowed to set hard in dry air 24 hours, then boiled for 24 hours, then kept five days in water, and then show upon test a tensile strength not less than 350 lbs., or only 50 lbs. less than that specified for seven-day normal briquettes. The average results of these boiling tests showed that the boiled briquettes gave 670 lbs., as against an average of 645 lbs., for the regular briquettes. The inspectors state that the experiments to date seem to indicate that briquettes boiled and then broken immediately after being cooled in water show approximately the same good results as when boiled and kept five days in water, which is the general custom prescribed by the specification.

Commenting in general upon the work of cement inspection, Mr. Wm. Barclay Parsons, in his first report to the Commission, says:

The work done by the department of inspection of material in testing cements has been exceedingly good. By locating the laboratory at the works and thus watching the manufacture of the cement from the quarry to the barrel, it has been possible to make many suggestions to the manufacturers, that resulted in a better and more regular product. In this inpection the manufacturer has cheerfully co-operated, and has been so impressed with the success of careful, scientific examination that he has supplemented our chemical laboratory with an additional one of his own. Investigations relating to the proper temperature in the burning of the cement have now been undertaken, and it is hoped will lead to still better results. The special quality of cement obtained was largely the result of a ruling requiring a specific ratio of increase in tensile strength from 7 to 28 days, and furthermore that cement showing as high as 750 lbs. at the earlier stage should be generally refused as unlikely to give good results in long-time tests.

The practical outcome of our close inspection has been the obtaining of a much higher grade of cement, as shown in the above tables, where it will be seen that during the year 1900, out of 3,102 briquettes, 174 failed, while during 1901, out of 27,389 briquettes only 43 failed, with a decided increase in the average results at every period of tests for both Portland and natural cement, whether neat or with sand.

UNIT STRESSES AND IMPACT IN OLD RAILWAY BRIDGES.*

By A. F. Robinson, M. Am. Soc. C. E.†

Since all railways have a certain proportion of old bridges still in use which are not adapted to existing engine loads, an important question is, What is the highest unit stress which may be permitted in old metal bridges, and how long will the structures be apt to last under this high loading?

These are questions for which some of us must find answers, as the very heavy engines recently put into service are causing unit stresses above what has been usually considered as the danger limit. Although called permanent structures, the life of the best designed metal bridges, when not overloaded, will seldom exceed 60 or 80 years. In all such cases the structure is supposed to receive the best of care as to repairing, painting, etc. The average life of metal bridges in America has not been more than 20 years, chiefly on account of the steady and comparatively rapid increase in rolling loads. In 1890, an engine weighing (with tender) 139 tons was by many engineers considered unnecessarily heavy as a standard in designing bridges. The Atchison, Topeka & Santa Fe Ry. did not begin to use the typical engines of this weight for designing bridges until 1893, and yet at the present time this company is running decapod engines which weigh (with tender) 196 tons, and have 116 tons on five pairs o. drivers in a space of 20 ft. The company has also consolidation engines with 96 tons on four pairs of drivers in a length of 15 ft. 4 ins., and prairie engines with 78½ tons on three pairs of drivers in a length of 13 ft., with 53,400 lbs. on one axle when the traction increaser is working.

On the Chicago Division of the A., T. & S. F. Ry., on an average about 30 trains pass during each 24 hours. Ten of these are passenger trains and eight of them are handled by prairie type engines. For an approximate estimate, we may consider that all freight trains are double-headers, making a total of 50 engines per day, and that each engine causes maximum stresses in the bridges. The maximum train-load is equivalent to only a little more than 3,000 lbs. per ft. of track, since no 24-ft. or 30-ft. ore cars are used. We will consider that the train-load causes maximum stresses twice as many times as the engine, making a total of 150 applications of the maximum each 24 hours. Therefore the floor system and main girders receive their maximum stresses 150 times per day, or on an average about one in 9 minutes. As a matter of fact, the maximum stresses will be received about six times within two or three minutes, while a train is passing, and then the bridge will rest from 10 minutes to 2 hours. On some single track roads it is quite probable that the bridges may receive their maximum stresses 200 times in 24 hours, or on an average once in about 7 minutes.

Wöhler's experiments show that, in tension, the rupture of iron bars was caused in the following different ways:

By	800	applications of	52,800	lbs.	per sq. in.
By	167,000	"	" 48,400	"	"
By	450,000	"	" 39,000	"	"
By	10,140,000	"	" 35,000	"	"

For ordinary short-span bridges, the dead load stress is only a small portion of the total. Under the heavy engines now in service, some of the old bridges have stresses of from 16,000 lbs. to 19,000 lbs. per sq. in. net, in the beams, stringers, and in the girders. We will assume three-fourths of the above maximum unit stresses as being due to live load, or 14,250 lbs. per sq. in. net. For impact and fatigue, we will add some 112% of the live load, making a total unit stress of 35,000 lbs. net, as follows:

Live load stress	14,250 lbs.
Impact, etc.	16,000 "
Static stress	4,750 "
Total	35,000 lbs.

Wöhler's experiments, as previously noted, show that for a unit stress of 35,000 lbs. per sq. in., the load was applied 10,140,000 times before the bar broke. According to this experiment, when bridges are strained to this maximum 200 times each day, they would last about 139 years, and if strained 1,000 times each day, their life would be almost 30 years. Can it be possible that these results, or anything approximating them, will be shown by our bridges in actual service? I fear not.

Wöhler's experiments above noted were in tension only, and there were but a few of them. In the beams and girders built within the past ten years, the bottom flange is proportioned for net section and the top flange is made like the bottom. Nearly all of the bridges built on the Atchison, Topeka & Santa Fe Ry. since 1890 have stiff laterals, and other details are made to conform to the very best practice, the object being to obtain very rigid structures that have the lateral swing reduced to the minimum. As a result of this, the bridges do not show as much movement or distortion under traffic as older structures. The increase in rolling loads since 1888 has been so great that but few bridges built prior to that time are now in service.

While some old bridges in which the main members were of cast-iron have broken under trains, there have been very few structures built of wrought iron throughout which have actually failed under trains. Bridges have been used for many years under a traffic which caused stresses that should, according to theory, have broken them down.

Some years ago the writer was very much surprised upon finding girder bridges that were standing under a traffic which gave unit stresses of 18,000 to 20,000 lbs. net. (These were not on the A., T. & S. F. Ry.) At that time the girders had been carrying this loading some five years, but they showed no signs of distress, and may be still in service. There are, I believe, many bridges which have stood from 5 to 15 years under a traffic causing stresses of from 16,000 to 20,000 lbs. per sq. in net, that were finally taken out for immediate causes other than the high unit stresses. These structures would have worn out nearly as soon under a much lighter loading.

During 1898 one of the large truss bridges on the Gulf Lines of the Atchison, Topeka & Santa Fe Ry. system was condemned because of high unit stresses, very faulty details, and a prospective further increase in the rolling load. The tensile stresses in the web members and chords were from 16,000 to 22,000 lbs. per sq. in net, while the height from base of rail to bed of stream was almost 50 ft. The beams had a unit stress of about 17,000 lbs. net, while the stringers were of wood and had been so reinforced that stresses were within safe limits. There were three spans in the bridge, 128 ft., 160 ft., and 260 ft. in length respectively, and they had stood under this heavy loading for about four years. When it was taken down, a careful examination of the pins and pin holes in the main truss members failed to show the slightest signs of serious wear. None of the bars had stretched enough to permit of measuring the elongation with a steel tape. I think the bridge would have stood for a good many years without showing signs of very serious wear, but it would not have stood any increase in the loading.

On nearly all of the large American railways there are old bridges carrying a traffic that causes stresses of from 18,000 to 20,000 lbs. per sq. in. net. Examination of the report of the New York Railroad Commission for 1891 shows that a large number of the bridges in that state were standing under traffic causing very high unit stresses. I have known of bridges in widely separated parts of the country which have stood for a good many years under very high unit stresses without giving indications of approaching failure. After these structures had been replaced, examination almost always showed the metal to have been but little injured. When through ignorance or carelessness, bridges have stood many years under high stresses, without attention or expert examination, are we not warranted in permitting almost equally high stresses on roads where the bridges are carefully watched and where they are removed upon the first marked indications of approaching failure?

Many experiments have been made by German, French and English engineers in order to determine the maximum loading that steel and iron bridges will stand which are considered as permanent structures. These experiments have usually been made upon comparatively small test pieces, and the load has not often been applied as it is in bridges in actual service. I do not believe these experiments warrant the conclusions drawn from them by many American engineers and applied in their practice. Experiments have not often been made upon full-sized girders or trusses, and some of these gave unexpectedly high results. I do not know of any experiments in which the load was applied in the same manner as in bridges under actual traffic.

It should be remembered that there is a very marked difference between the unit stresses permitted when designing a new bridge, which is a permanent structure, and those allowed in an old bridge whose life at best can be but a few years. In the new bridge provision is made for the certain increase in the weight of motive power and rolling stock, for the probable waste in section from rust, for the uncertain factors called impact and fatigue, and for a safety factor.

This is accomplished, either by making the live load unit stress sufficiently low to cover all of the factors, or by adding a variable percentage to the live load stresses for impact, etc., and considering the combined stresses as though static. In the old bridge the maximum possible increase in rolling load has been received, it is thenceforth only a temporary structure which is to be worked to the highest safe limit for a short time and then be replaced. The exact length of time the old bridge can be used must be determined by the signs of distress it shows under the heavy loading. Of course these old bridges require much more attention than new ones, they need constant watching and very frequent thorough examinations.

A good many experiments or series of tests have been made, in attempts to determine the exact effects of the rolling load, and with special reference to impact. In these experiments, instruments are clamped to the various members of a bridge, which measure the exact increase or decrease in the length of same under the rolling load; from this the exact stresses in the members under test have been determined. While these investigations are in the right direction, they have been comparatively so few in number, and so disconnected, that no definite conclusions should be drawn from them. The elongations or contractions have been taken from only one or two members of a bridge at any single passage of a train, and changes in length are so slight that the results have to be multiplied many times by the recording machinery, in order to be shown graphically. Under these conditions, an exceedingly small error by the recording machinery will show results much greater than they actually are.

The results obtained by different operators with quite similar instruments have not been uniform. Also results obtained by one operator on different bridges have shown much irregularity even when the bridges themselves were quite similar. I do not believe the investigations thus far made warrant the great effect given to impact by the investigators and by many engineers. If the impact has the full effect it is credited with, then many old bridges still doing good service should have fallen down years ago. Impact undoubtedly has some effect, but in my opinion this is hardly comparable to what has been charged to it. One item that should reduce the effects of impact is the distributing power of the track rails and the spring of the ties, the bridge therefore not receiving anything like the full force of the direct blow or impact, which it is commonly assumed to receive.

While the conclusion of all investigators has been that iron or steel might be stressed an infinite number of times below the elastic limit without injury; they have been almost equally positive in the conclusion that, after receiving a stress much beyond the elastic limit, a permanent change of length takes place. After the metal has been stressed much beyond the elastic limit, the load can be applied only a definite limited number of times, and it may break under a load that is less than the one causing the first permanent set. Just how many times this high stress can be endured by a bridge depends upon the distortion caused thereby.

Possibly a bridge might be so designed that the distortion would cause such serious wear as to require its removal, even though the stresses were not actually above the elastic limit of the metal. A bridge so designed as to reduce the distortion to its lowest limits, would outlast the one above noted, even though the unit stresses were above the elastic limit of the metal. In general, I believe excessive distortion causing abnormal wear in the members has more effect on the life of a bridge than the actual amount of stress.

In well designed bridges, unit stresses of from 16,000 to

*Abstract of a lecture delivered at the University of Illinois.

†Bridge Engineer; Atchison, Topeka & Santa Fe Ry., Topeka, Kan.

20,000 lbs. net may be permitted for a time in case of necessity. This it should be noted, however, is one of the last methods by which a little more service can be obtained from an old bridge. A much better plan would be to re-erect the old bridges on branch lines where traffic is lighter and where they should last many years. This plan, however, cannot always be followed. Under these high unit stresses, a bridge may last anywhere from 2 to 10 or 15 years, depending upon the amount of distortion caused by this loading.

It must, however, receive the closest watching and have every sign of distress noted. As soon as the evidences of serious wear become fully marked, the bridge must be removed or supported by falsework. I do not think that under these or even higher unit stresses the bridge will fail without giving due notice of the approaching failure. Further, I believe that every bridge which has failed (cast-iron chords and connections excepted) would, if examined, have been found to show what should have been an ample warning to an intelligent examiner, for a metal bridge will not, like the "one horse shay," go all at once. The camber is one of the important points to be observed; as long as it is uniform or regular there is little danger, but falsework supports should be put in at once when any irregularity is found in the line of camber.

It must not be inferred that I am advocating the general adoption of these high unit stresses in old bridges. They should be permitted only as a last resort, after a careful consideration of each case, coupled with a thorough knowledge of the bridge and its previous record. It should be remembered also that while the Atchison, Topeka & Santa Fe Ry. has been referred to in this paper, the general statements apply to almost every large railway system in the country.

SURMOUNTING GREAT ASCENTS IN WATERWAYS.

At the late International Navigation Congress, held at Dusseldorf, several papers were submitted discussing the best arrangements for overcoming great and abrupt differences in level in artificial waterways. The important elements to be considered in such a discussion are: Cost of construction, maintenance and operation, economy of time and water, ease and simplicity of repair and comparative liability to accident.

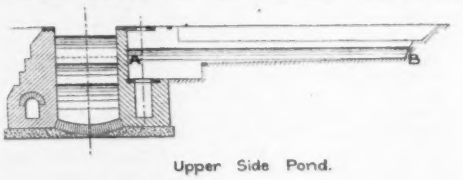
Lieut.-Col. C. W. Raymond, Corps of Engineers, U. S. A., submitted one of these papers, and he classifies the appliances of this nature actually employed, as ordinary canal locks, inclined planes and mechanical lifts acting vertically. The two last-named have not been practically applied to the service of vessels of large draft; and for large waterways navigated by vessels of great weight and volume the ordinary lock has the important advantages of cheapness, simplicity and safety, especially when the lift is not excessive.

Lieut.-Col. Raymond then proceeds to discuss the locks proposed by the U. S. Commission for Deep Waterways, already described in this journal. In his summary he notes the more important points referred to in the paper, as follows: (1) The ordinary lock is the best arrangement yet devised and practically tested for overcoming differences in level in waterways of large dimensions. (2) With a large number of locks, single-vessel locks, which facilitate the rapid passage of the individual ship, are preferable to fleet locks, which increase the total volume of freight that can be passed in a given time. (3) It is generally desirable to have an intermediate gate dividing the lock chamber into two unequal parts, to facilitate the rapid passage of small vessels and to save water. Guard gates at the head and foot of each lock and flight are necessary to facilitate quick emptying. (4) It is practicable, and in some cases desirable, to adopt lifts as high as 52 ft., and gates can be constructed to safely sustain the resulting pressure. (5) Culverts for filling and emptying should be placed in the walls, instead of under the floor, unless the lift is moderate and the foundation strong rock. (6) Portland cement concrete will answer for most of the masonry. (7) The lock gates adopted were miter-gates of steel, selected as the best. (8) One side only of the gate is sheathed, leaving the interior open for inspection and painting. (9) The bearing pieces at the meeting faces of the gates should have a cylindrical form of large radius, and should be of wood, unless the thrust of the gate is so great as to require steel. (10) With lift and pressure large, the horizontal type of gate framing is preferable to the vertical type. (11) For the shape of the gate in plan the girder form is preferable to the arch form.

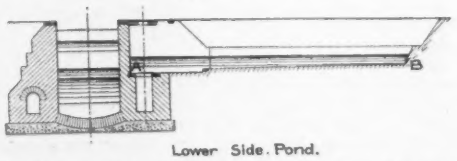
The next report was presented by Mr. Em. Lefebvre, of Brussels, and described the locks on the Charleroi-Brussels Canal. This canal was opened to traffic in 1832, and in 1879 a law was passed authorizing its enlargement throughout its whole length of 46 miles. This improvement is still in progress.

The interesting feature of this paper is a description of the method adopted for economizing water by building at each lock two side storage ponds. These side-ponds are fan-shaped in plan, terminating in two wells located in the side wall of the lock, each well 7.8 ft. diameter. Through the center of the side-pond, and dividing the two wells, is a wall separating the pond into two equal parts. The wells mentioned are immediately over the filling and emptying culverts, and in the middle of each well is a cylindrical sluice-gate permitting communication with either of the culverts mentioned; and these gates are located in a basin, with the bottom of this basin 1.15 ft. above the water level of the lower reach.

The accompanying cut shows the working conditions of these side-ponds, before and after locking has taken place; the ponds are assumed to be working under normal conditions, and to be filled to the level of A B. A layer of water, 3.11 ft. deep, is emptied from the lock into the upper half of the side-pond, leaving a final head of 0.67 ft. at the outflow. A layer of water, 2.71 ft. deep, can then be emptied into the lower half of the side-pond, leaving a final head of 1.9 ft. The contents of each pond above the line A B can be emptied in succession into the lock, with final heads of 0.65 ft. and 0.91 ft. The efflux, therefore, always takes place under pressure, and during the whole operation of locking the orifices are under water and the discharge is of constant section. In this way 425 cu. m. of water can be saved without reducing the rate of locking or about half the total quantity required for filling the lock. Actual practice has shown that time has been saved when



Upper Side Pond.



Lower Side Pond.

Sections of Side Ponds for Economizing Water in Canal Locks.

only 6.7% of the volume of the full lock was utilized by the side-ponds. The two side-ponds at each lock cost about $482,000, as compared with $3,536,256 for the locks themselves.

In discussing the time consumed in passing the lock, the following notes are made: The lock-gates can be opened or closed in 35 seconds, the sluice-gates are lifted in 10 seconds, and the boats in the lock rise or fall at a maximum rate of 0.164 ft. per second. The upper half of the side-pond can be filled with 227 cu. m. of water in 1 m. 12 s.; this volume of stored water can be returned into the lock-chamber in 1 m. 8 s. The lower pond can be filled with 198 cu. m. of water in 1 m. 4 s., and this returned to the lock-chamber in 1 m. 27 s. A boat of 300 tons can be locked through in 14 m. 25 s. without using the side-ponds, or in 16 m. 11 s. by using the side-ponds in economizing water. The time for an ascending boat is 15 m. 25 s. and 17 m. 30 s., respecively. This time is for passing a lock of 13.84 ft. lift. By using the side-ponds the time of transit is increased 1 m. 46 s., or 2 m. 5 s., but 425 cu. m. of water is saved, or about one-half of the volume required to fill the lock. The author remarks that the side-ponds are only used when the ordinary water supply is low, and in larger locks time can be saved by having two sets of side-ponds and by operating the gates by hydraulic or electric power.

In a third paper Messrs. Genard and Denil described the vertical hydraulic lift for boats on the Canal du Centre, in Belgium. These lifts are of the hydraulic type designed by Mr. Edwin Clark, M. Inst. C. E., then of the English firm of Clark, Stanfield & Clark. The dimensions of this lift, compared with others of a similar type, were given in Engineering News of April 18, 1895.

AN ENGINEERING COMMISSION ON THE ARTESIAN WELLS OF THE MEMPHIS WATER-WORKS.

Information regarding the yield of a group of artesian wells through a series of years is always at a premium, and we therefore take pleasure in presenting the results of a recent study of the notable artesian well system belonging to the Artesian Water Co. of Memphis, Tenn. The study forms a part of a recent report by Messrs. Arthur Hider, J. A. Omberg, Jr., and A. T. Bell,* a commission of engineers appointed by the city authorities of Memphis to report among other things on the "condition and value" of the works of the Artesian Water Co.

Before taking up the study it is desirable to make some preliminary statements designed to give a clearer understanding of the situation. The artesian water supply of Memphis, which displaced water drawn from the Wolf River,† was introduced in or about 1889, and has since been increased from time to time to keep pace with the growth in consumption, and to make good the diminished yield of the wells. The population of Memphis, it may be added, was 64,495 in 1890, and 102,320 in 1900. The wells draw from a stratum of sand about 350 ft. below the surface of the ground, overlaid by impervious clay. Excluding two wells which do not appear to have been successful, 102 wells have been sunk, and 42 have been abandoned, leaving 60 now in use. The internal diameters of the casings of the wells have ranged from 6 to 13 ins., but only one of the latter size has been used, and, with that exception, all the wells now in service have an effective diameter of either 8 or 10 ins., mostly the latter. The depths range, in round numbers, from 200 to 500 ft., generally being about 350 ft. The casings extend the full depth of the wells, and each well is provided with slotted strainers.

The early wells were temporarily connected by piping at the ground level, but in 1890 a tunnel system was completed, by means of which the water is conducted by gravity to a deep pump well. The first well was begun in the fall of 1887. The date of its completion is not given, but the report already mentioned states that the next 37 wells were finished in the fall of 1889, and Nos. 39 to 42 in March and April, 1890. This statement, however, does not agree with other accounts, from which it appears that wells 21 to 31, inclusive, were connected and tested in May, 1888, and that others were in use a few months later. The essential fact, however, is that the first 42 wells were put in use, approximately, or as an average, in 1889.

The natural pressure of water in these wells, before the artesian basin was drawn down by pumping, is variously described as being sufficient to deliver the water all the way from not quite at the natural surface to 6 or 7 ft. above. A pumping test of eight wells made in May, 1888, gave a total daily yield of 2,500,000 gallons, and lowered the water to 23 or 24 ft. below the ground surface. The effect of pumping during subsequent years will be discussed later on. It may be added that the first wells were much closer together than those sunk after the engineers assumed charge. The tunnel system connecting the several wells consists of a main tunnel, 75 to 80 ft. below the surface, and drifts to each well. The tunnel is oval in shape, about 5 ft. in diameter. The drifts are rectangular, lined with 3-in. oak, and the water is conveyed through the drifts in terra cotta pipes. Specially designed tees at the junctions of the drifts and tunnel, together with wooden balls, make it possible to shut off the wells, and shafts and gates enable the company to cut out and

*The address of the first named is Greenville, Miss.; of the last two, Memphis, Tenn.

†The original works were built in 1872, by the Memphis Water Co. which failed and was reorganized in 1879. There was dissatisfaction with the river supply, and, an artesian well having been sunk and proved successful by other interests, a franchise was granted to the Artesian Water Co. in 1887. Both companies began to sink wells, and in 1889 they consolidated, and the Wolf River supply was abandoned.

pump out sections of the tunnel with their connecting wells.

The three 10,000,000-gallon Worthington high-duty vertical pumps rest in a pump pit 47.56 ft. in depth from its concrete foundation to the surface of the ground. Beneath this is the wet or pump well, 30 ft. in depth, covered with a plate through which the suction pipes extend downward, and from which a 30-in. wrought-iron stand-pipe, 56 ft. high, is carried upward. The top of the stand-pipe is 85 ft. above the bottom of the wet well. The water ends of the pumps are 45 ft. below the ground level. The stand-pipe, it will be seen, balances the fluctuating pressure of the water from the wells and relieves the work of the pumps to a corresponding extent.

Fig. 1, from the report of Messrs. Hider, Omberg and Bell, hereafter called the engineer's report, shows the location of the wells sunk up to and including June, 1902. Fig. 2, from the same report, gives some idea of the material penetrated by the wells, and of the tunnel, drifts and shafts.

The engineers, after giving some general information regarding the wells, and stating that the water yielded is most excellent in quality and that in quantity it has thus far proved ample, proceed to discuss the permanence of the supply as follows:

The quantity of water which will flow from any one well will depend on three factors, namely: The head of pressure at which it discharges, the size of the pipe, the freedom with which the water enters the well at the strainer. In the case of a number of wells, the aggregate discharge is governed by the same conditions. Observations of the total discharge from the supply under very different conditions extending over four years, show very plainly the effects of varying any of the three factors named above.

Fig. 3 shows the relation between the pumpage and draft, or, in other words, the total quantities of water yielded from the supply at various heads of flow.

Experiments on individual wells has shown that the quantity of water discharged from a given well varies directly with the head of flow, i. e., if a well flowing

Fig. 1. Map Showing Location of Artesian Wells, Drifts, Tunnel and Shafts at Memphis, Tenn.

under a given head, yield a given quantity of water per second, at twice the given head the quantity of flow will be approximately doubled. If this be true for each individual well of the system of supply, the total yield from a system of a fixed number of wells should bear a constant relation to the draft or head of discharge. A comparison of the rate of pumping and the corresponding draft, or lowering of the level in the wet well (the amount of such draft indicating the head of flow of wells) shows this to be approximately true through any short period of time. If this relation remained constant through the period of observation, the curves of pumpage and draft shown by Fig. 3 would be identical, if the ordinates of curve of pumpage and those of curve of draft were so assumed that the relation of distances representing units of pumpage and units of draft were the same as the constant relation between pumpage and draft. For example, if it were found that for every 4 ft. of draft there were about 1,000,000 gallons of water per day discharged, then the spaces on pumpage curve representing 1,000,000 gallons should be equal to that on draft curve representing 4 ft. of draft.

PUMPAGE AND DRAFT.

This relation of 4 ft. of draft per million gallons per day was found to be close to the average of the true relation between pumpage and draft, and the curves were plotted on that basis, but a glance at the diagram shows that the draft, while showing variations corresponding to change in pumpage, is far from identical or approximately parallel to it. This discrepancy is due to a variation in the relation between the flow and head, which is evidently due, in turn, to the variation in the other two conditions determining flow, viz., size of wells and the freedom with which the water enters the strainer. By size of wells is meant the aggregate sectional area of the wells, or the number of wells. The number of wells in use since 1897, the beginning of this record, has been nearly constant, so that the amount of discrepancies between the two curves represents, approximately, the comparative freedom with which the water entered the strainers.

In the upper part of Fig. 3 the amount of the variation from the constant relation between flow and head is shown diagramatically, and represents the relative condition of the supply at various times.

MAXIMUM YIELD.

With a given condition of supply, represented by a point on the curve, we are enabled to easily determine approximately the maximum probable yield from the system of wells in use at that time, at suction limit, or maximum draft in wet well possible. In October, 1899, the condition of the supply system was at its worst, showing that at that time, with that system of wells, the maximum rate of yield possible was only about 10,200,000 gallons per day, a rate which would be totally inadequate to supply the present demand. This condition was due to the abandonment of an old battery of wells shortly before. The very marked improvement during the next six months, showing the ultimate rate of yield at suction limit to have increased to about 19,000,000 gallons per day, was due to turning on 13 new wells. The same marked improvement is shown where 19 new wells were turned on in January, 1901, though the improvement due to the 19 new wells is not proportionately greater than that of turning on the 13 new wells about January, 1900, because of the greater average quantity pumped reducing the general head of flow from the system.

In this connection it will be noted from the diagram that the increase in rate of yield due to increasing the number of wells is not entirely permanent, but gradually falls away, and in the course of a year or two almost disappears.

This is due to the deterioration in the condition of the individual wells. Tests of the flow from individual wells show that the discharge is always much greater shortly after first being turned on than after it has been in service for a time. This rapid reduction of the average flow is to be expected—is unavoidable—and does not in any way represent a depreciation of the well. It is due to the voids in the average coarse sand around the strainer becoming more or less filled by finer sand from the surrounding area, which is carried by the water flowing toward the well.

DEMAND IS INCREASING.

An average condition of a supply of about 50 wells for the past four years shows a rate of yield of 14,900,000 gallons per day at suction limit. By cleaning strainers and sinking more wells this maximum may be brought up greatly. Observation of the curve of condition shows that on July 1 this limit of supply was about 17,500,000 gallons, and had been raised to that amount by flushing strainers since April, when it was about 16,500,000. On July 18 six new wells were connected, and increased this total to about 19,000,000 gallons per day, from which it may probable recede during the next four months to about 17,500,000 gallons per day.

Memphis is growing quite rapidly, and there will in a short time undoubtedly be a demand for 20,000,000 to 30,000,000 gallons per day made on its water supply. The limit of capacity of the present station will be reached very shortly, and it will be necessary to increase the capacity of supply to anticipate the demands of a city of a quarter of a million people. The consideration of a corresponding increase in the size of pumping capacity, auxiliary station, etc., are mentioned in another section of this report, and will only be considered here with reference to adequacy of supply.

The ultimate of yield of supply referred to above does not mean the ultimate rate obtainable from the artesian sand at that point, but the maximum rate of yield from the systems of wells, under existing conditions, already in use at time of observation.

The ultimate maximum rate at which water can be obtained from a given area is the rate of flow from the maximum number of wells possible to sink in that area, a condition reached when the whole area is [illegible] well. It needs no reflection to see that such a [illegible] can never be reached, but can only be approached [illegible] proving the condition of the wells and increasing [illegible] number to the limits of economy.

CONDITION OF WELLS.

By the condition of the wells generally, is meant the condition of the material immediately around the [illegible]. If there is a small stratum or pocket of clay in proximity to the strainer, the strainer slots quickly become clogged and the well flow is diminished according[ly]. If the well be made in a good quality of coarse sand the flow is good when first started, but gradually deteriorates

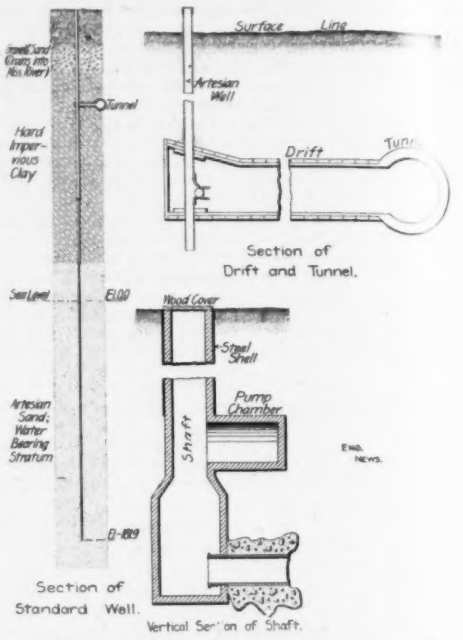


Fig. 2. Details Memphis Wells and Tunnel Connections.

in quantity. This deterioration is due to the finer sand being carried by the comparatively large velocity of flow toward the strainer in the voids of coarser sand, and finally depositing in these voids and impeding the flow as greatly as if the well was in fine sand.

If there are indications of clay in proximity to a strainer, shown by whitish or "milky" water, the well had probably better be abandoned, and the casing drawn and utilized elsewhere.

When a well made in good sand shows considerable decrease in flow, flushing should be resorted to, to improve its condition. By flushing is meant the forcing from the inside of the strainer a stream of water under considerable pressure through the slots and into the sand. The effect is to wash away from the coarse sands surrounding the strainer, the fine sand which is impeding the flow of the well. This is accomplished by an ingenious tool devised for this purpose, which confines the water to a small section of the strainer, insuring a much more thorough cleansing than is possible by merely forcing a stream of water down the well and allowing it to dissipate through the parts of the strainer offering least resistance, or those parts already in best condition.

FLUSHING THE WELLS.

Fig. 4 shows diagrammatically the result of flushing with this tool. An average of four wells shows a falling off in flow of about 32½% during nine months, after which flushing was begun and increased the flow about 70%, or about 13% above the original condition at beginning of the record. The same exhibit shows, for comparison, wells which have not been flushed.

The flushing tool mentioned above has been in use only since April, 1902, hence no extended period of observation is available, but the results thus far give grounds for the opinion that the present supply system can be increased by about 20% by its use.

The effect of this flushing seems to wear off in about three to five months. The expense of each flushing at present is about $70, making a maintenance charge of about $23 per month per well, on a basis of flushing four times a year, in order to maintain a 19,000,000 or 20,000,000-gallon supply.

In order to obtain and maintain a supply greater than this, or to obtain an absolutely reliable supply of this size, it will be necessary to increase the number of wells.

If each additional well sunk increased the supply in proportion to the number of wells, there would be no limit to the supply obtainable by adding to the number of wells. But such is not the case. Each new well sunk diminishes the flow from the existing wells, and provides an additional quantity of water equal to the difference between its own flow and the diminution of the aggregate flow of

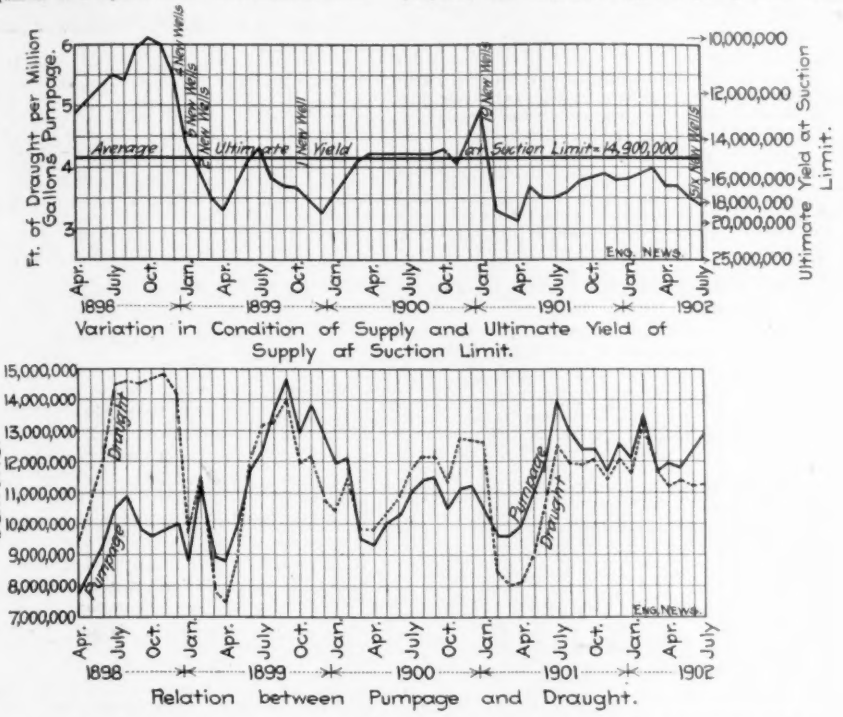

Ft. of Draught per Million Gallons Pumpage.
Ultimate Yield at Suction Limit.
Average
Ultimate Yield
Jet Suction Limit=14,900,000
Eng. News.
Apr. July Oct. Jan. Apr. July Oct. Jan. Apr. July Oct. Jan. Apr. July Oct. Jan. Apr. July
1898 1899 1900 1901 1902
Variation in Condition of Supply and Ultimate Yield of Supply at Suction Limit.
Ft. of Draught. Gallons.
Draught
Pumpage
Eng. News.
Relation between Pumpage and Draught.

FIG. 3. DIAGRAMS SHOWING PUMPAGE FROM MEMPHIS WELLS AND ULTIMATE YIELD.

mum amount possible to obtain from that area would be obtained when the whole area was converted into one vast well of one-quarter of a square mile sectional area. The quantity of water which could be obtained from such a well can be determined if we assume that the quantity of discharge will vary directly as the draft, an assumption we know to be erring on the safe side through our range of observation. Data for this estimate were obtained from an observation of the depth of draft in wells balled out (i. e., tunnel connection closed and water allowed to reach its static level), in close proximity to the area of supply, at various depths of draft in pump well. At a draft of 35 ft. in pump well the draft in the balled off well was 22 ft.; at pump well draft of 50 ft. the draft in well was about 29 ft., showing a difference of about 8 ft. of draft in level to 15 ft. difference in draft in area of supply. The pump well drafts of 35 and 59 ft. represent respectively about 8,750,000 and 15,000,000 gallons per day, or a difference of about 6,250,000 gallons per day, which causes the 8 ft. increase in draft of static level in areas contiguous to supply area. At maximum supply obtainable this static level would be reduced to level of supply area, or about 60 ft. In order to do this a supply of nearly 800,000 gallons per foot of decrease would have to be disposed of. This indicates an ultimate supply close to 50,000,000 gallons per day as the absolute maximum from a limited area.

The economical limit of quantity from a given area beyond which it would be impracticable to go is probably in the neighborhood of 25,000,000 to 30,000,000 gallons per day.

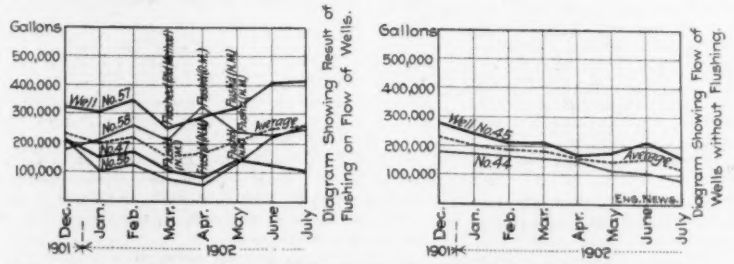


FIG. 4. DIAGRAMS SHOWING YIELD OF MEMPHIS WELLS WITH AND WITHOUT FLUSHING.

The engineers next consider the best means of increasing the present supply by sinking more wells and placing a 15,000,000-gallon pump in the space already provided for a fourth pumping engine. After making estimates for auxiliary wells, with air-lift pumps and a 10,000,000-gallon reservoir, and for an extension of the present well and tunnel system, they conclude that the latter would be the cheaper. The estimate of cost for the extension recommended is as follows: 5 shafts, $13,750; 30 new wells, $90,000; 2,500 ft. of drifts, $20,000; one 15,000,000-gallon pump and boilers, $72,000; total, $195,750, plus the usual 15%, $225,113.

AN INDEPENDENT WELL SYSTEM AND ITS RELATION TO THE PRESENT WELLS.

This proposed increase of supply to a safe daily total of about 25,000,000 gallons would suffice for only some five years, when, if the foregoing assumptions be accepted, an independent supply would be required. The relative advantages of a new system of wells and a supply of water from the Mississippi River, with filtration, are considered in detail, and it is concluded that there is a difference of $1 per 1,000,000 gallons in favor of the artesian wells, besides the advantage of continuing a source of supply which is so satisfactory to every one, and which appears to have contributed so materially to the growth and prosperity of the city. The brief discussion of the best location of an independent well system, with the estimate of cost, is as follows:

In providing a supply in excess of the economical limit of the present system, it is well to anticipate the demand by 20 years or more, or to provide for a total supply of 50,000,000 to 60,000,000 gallons per day. This would require an entirely independent system, in many respects a duplication of the present.

Fig. 5 shows the probable effect of the present station on the hydraulic slope in the surrounding area.

This diagram shows very plainly that the present supply is at the apex of a cone of abstraction or depression of the level, and in locating a new system, which will in turn become the apex of another such cone, care must be taken that it is practically outside the influence of the existing station.

From the diagram it is seen that, at a distance of about four miles from the present station, the effect of draft is very little more than it would be several miles further away, and indicates that it might be safe to establish a new supply at this distance from the present station.

In the dotted lines is shown the probable effect on the draft at points between the two stations, assuming one location at B, each yielding about 15,000,000 gallons per day, and drafting water in wet well to about the same elevation as in present station.

While under these conditions it appears that a station at B would be perfectly feasible, it is impossible to predict just what the conditions might be were each station yielding about 30,000,000 gallons per day. The effect on the slope of the increase of quantity pumped is plainly indicated by the diagram, which shows the difference in the hydraulic slope in 1898, when about 9,000,000 gallons per day were pumped, and in 1902, when the daily average is about 12,000,000 gallons. On this account it would perhaps be safer to remove station B even further from the present station than the four miles assumed.

While it is true that each of the stations will tend to slightly diminish the yield of the other, there is no doubt but that by thus increasing and separating the number of areas of supply, the total rate of yield from the artesian supply can be made sufficient for a city of any size for an indefinite time to come.

The probable cost of an independent station with wells, drifts, tunnels, pumps and additional mains necessary is given below:

50 10-in. wells at $3,000	$150,000
10,000 ft. drifts at $8	80,000
5,000 ft. 5-ft. tunnel at $18	90,000
Shafts, auxiliaries, gates, etc	45,000
Pump pit, etc	40,000
Building	40,000
Stacks	15,000
Boilers	15,000
Pumps, machinery, etc	200,000
Main connecting to present distribution system, say 10,000 ft., at $10	100,000
	$775,000
15% for engineering and contingencies	116,250
Total	$891,250

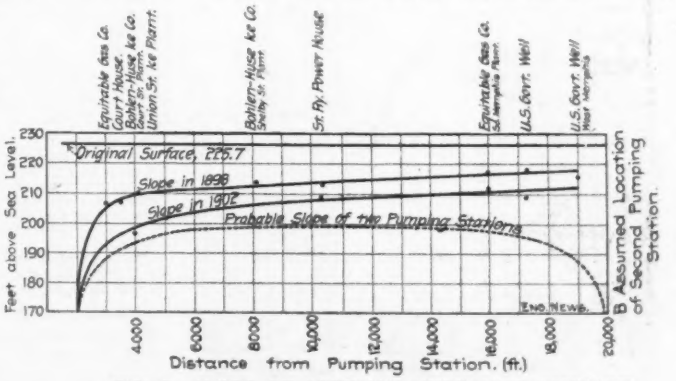

Equitable Gas Co. Court House
Bohlert-Huse Ice Co. Court St. Plant.
Union St. Ice Plant.
Bohlert-Huse Ice Co. Shelby St. Plant.
St. Ry. Power House
Equitable Gas Co. Memphis Plant.
U.S. Govt. Well
U.S. Govt. Well Near Memphis
Original Surface, 225.7
Slope in 1898
Slope in 1902
Probable Slope of two Pumping Stations
Feet above Sea Level.
B Assumed Location of Second Pumping Station.
Eng. News.
Distance from Pumping Station. (ft.)

FIG. 5. SLOPE OF ARTESIAN HYDRAULIC SURFACE AT MEMPHIS AND PROBABLE EFFECT OF A SECOND PUMPING STATION.

DEPRECIATION OF THE OLD WELLS, DRIFTS AND TUNNELS.

This section of the engineers' report includes a tabular description of each of the 104 wells sunk by the company, giving the diameters and lengths of the casings, date of boring the wells, whether the tops are opened or closed, and remarks on the history of some of the wells. In place of reprinting the table we have made the following summary of one or two of its features, not summarized in the report:

Of the first 42 wells, 16 were 6 ins. and 26 were 8 ins. in effective diameter. Of the 18 sunk in 1892, 8 were 8 ins. and 10 were 10 ins. in diameter. Of 13 sunk in 1898, 2 were 8 ins. and 11 were 10 ins. in diameter. Of the 29 sunk and put in use (two others abandoned) during the years 1899 to 1902, inclusive, 1 was 8, 27 were 10, and 1 was 13 ins. in diameter. Or of the 60 wells now in use, 11 are 8 ins., 48 are 10 ins. and 1 is 13 ins. in diameter. This gives a total area of about 31 sq. ft.

The engineers' report, after giving the table, proceeds as follows:

This statement shows that the first 42 wells, sunk in 1889, were abandoned in 1899, after ten years of service.

indicating that the depreciation on these wells was about 10% per annum.

From these wells much was learned of the art of well making, and the standard well of to-day, besides giving a much greater yield of water, will no doubt show a much longer life.

The older wells were generally of single casings of 6-in. or 8-in. wrought-iron pipe, while the present casings are of heavier 10-in. steel pipe, with specially protected threads, and an outer or protection casing of 13-in. steel pipe.

Just how much the life of a well of this kind exceeds the life of the pioneer type is impossible to say. That it is much longer is shown very positively by the fact that the 18 wells sunk in 1892, ten years ago, are still doing good service and show practically no effects of age.

The life of the casing is the limit of the life of the well, since by periodic flushing its condition can doubtless be maintained for a very long period of time.

The life of a steel casing inaccessible for painting or repairs can hardly be estimated greater than about fifteen years, or on a basis of 7% depreciation per annum.

From the following approximate statement of the age of different wells an average of depreciation is obtained:

Approximate age of	18 wells	10 years
" " "	13 wells	4 "
" " "	19 wells	2 "

Ten new wells.

Giving a total depreciation of 30% in the 60 wells.

A close personal inspection of the drifts recently completed shows no sign of leakage.

The following comparison of the metered flow of the wells and the total amount of water pumped shows no discrepancy greater than that which might be due to errors in observation:

Date, 1902.	Well metering.	Pumpage.	Pumpage excess.
January	9,720,000	10,086,600	366,600
February	13,440,000	13,375,000	—65,000
March	11,347,000	11,118,000	—229,000
April	13,337,000	12,973,200	—363,800
May	10,491,000	11,072,300	581,300
June	12,537,000	12,466,600	—70,400
July	13,113,000	13,195,100	82,100

The depreciation of this part of the system is doubtless very small, and is reasonably taken at 1% per annum.

The following statement of the age of the different portions of the underground construction shows a total depreciation to date of about 9%.:

2,842 ft. drifts	13 years	old
4,396 " "	10 "	"
2,841 " "	4 "	"
3,924 " "	2 "	"
1,880 " "	New.	
5,024 " tunnels	13 "	"
Pump. pit, wet well, etc.	13 "	"

EARLY STUDIES OF THE ARTESIAN WELL SYSTEM OF MEMPHIS.

The recent study of the yield and permanency of the Memphis artesian wells, presented at length in the preceding article, deals chiefly with the conditions of the last four years or so. On April 25, 1898, Mr. John Lundie, D. Sc., M. Am. Soc. C. E., submitted to the city council of Memphis a report on the works of the Artesian Water Co., in which

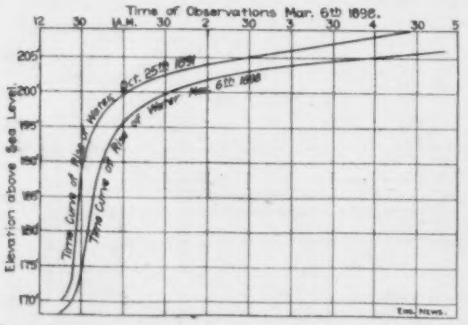


Fig. 1. Static Level of Water in Memphis Artesian Well System on Shutting Down Pumps, Oct. 25, 1891, and March 6, 1898.

he presented some studies of the yield of the wells at that date, and also for a number of preceding years.

On March 6, 1898, at midnight, the pumps of the Artesian Water Co. were shut down and the levels of the water as it rose in the stand-pipe connected with the well and tunnel system were noted at short intervals. One of the curves on Fig. 1 is a graphical exhibit of the observations. The water rose rapidly through a distance of 30 ft., then more slowly,

showing that at first the water was forced up through the wells under considerable pressure, indicating a correspondingly high head in the immediate vicinity of the wells; after which it was evident that the water had to percolate from a greater distance through the sand under the influence of a more and more distant head.

A second curve on the same diagram shows what took place under similar conditions on Oct. 25, 1891, when only the original 42 wells (see other article in this issue) had been sunk. The two curves show the diminished head on the wells after a period of nearly eight years.

Fig. 2 shows the hydraulic slope of the artesian water surface in the vicinity of the water-works wells as observed in March, 1898. It was obtained by measurements on other and surrounding wells, pumping from which was suspended for the time, the water-works pumps meanwhile being kept in operation. Mr. Lundie states that:

The fact is proven that at a distance of from 500 to 600 ft. from any of the water-works wells the level of the artesian water plane has risen to such an extent as might justify the sinking of additional wells.

It will be noted that the elevation of the water in the wells gaged nearest to those of the water-works system corresponds to the level to which the water rapidly rose on making the test at the pumping station already referred to, and the slope of the water plane from that point back corresponds to the distance to the rising level in the station stand-pipe during the test plotted on time intervals (Fig. 1).

Observations at the wells and stand-pipe showed that the

level of the water in the pump well is at all times the same as that of the various wells of the system (which) . . . . . could not well be otherwise, as the water

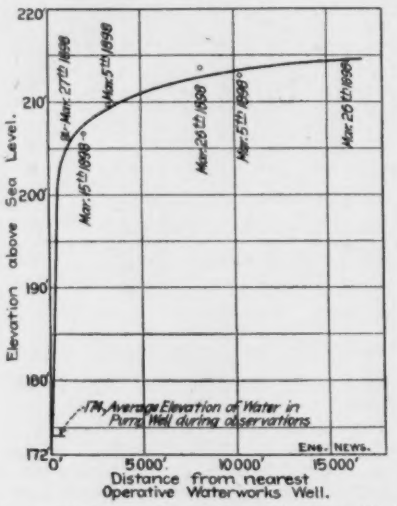


Fig. 2. Hydraulic Slope Near Memphis Wells, March, 1898.

tunnels virtually form a reservoir and the slope due to the flow of water through the tunnels is slight.

Mr. Lundie's conclusion regarding the permanency of supply was that it

is inexhaustible and that it is limited only as the supply from any spring or river has its natural limitations by the rate at which it is called on to yield water.

One of the most interesting sections of the report describes the meter used to determine the yield of each well, as follows:

The yield of individual wells has been measured by means of a specially constructed meter, consisting essentially of a revolving wheel having blades on it similar to those of a ship propeller. By actual measurement there has been determined the number of gallons passing through the meter for any given number of revolutions per minute, and tables made from this calibration have been used in recording the flow of the wells by reference to the rate at which the water flowing upwards through the tube turned the wheel. The writer checked this calibration by weir measurement.

The aggregate yield of the wells exceeds the pumpage as measured by the plunger displacement, and after allowing for a reasonable slip the pumpage seems to be continually gaining on the meterage (see Fig. 3), indicating "that some water is being pumped which is not coming up through the well tubes." Some of this may be accounted for by under-registration of the well meters on very light yield. On indicating the engines, Mr. Lundie concluded that the slip of the pumps was not excessive. The only two ways, the report states, of accounting for the pumpage excess are (1) that water from the artesian stratum finds its way up the outside of the casing, and (2) that water enters the wells from the water-bearing stratum above the clay, through leaky tubes. The section of the latter subject to fluctuations in water level "are particularly liable to corrosion," and "there is little reason to doubt that a number of wells are leaking owing to such action." Furthermore,

the fact that many of the wells cannot be operated owing to their rendering the water turbid, seems to point to sand or clay finding its way through the well tubes above the impervious stratum, rather than to sand being thrown up through imperfect strainers. No doubt the latter effect does occur to some extent as may also occur some flow up the outside of the tubes.

At the date of the report (April 25, 1898) Mr. Lundie stated that of the 60 wells sunk, 24 were then "inoperative from one cause or another." As

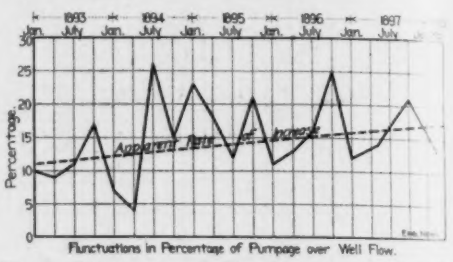


Fig. 3. Percentage of Pumpage from Memphis Wells Over Aggregate of Meter Indications for Each Well, 1893-8.

is shown elsewhere in this issue, 18 more of the early wells were abandoned shortly after Mr. Lundie made his report, and it should also be added, in justice to the wells now in use, that many of them have extra casings.

Notes on eleven wells outside the water-works system show four that had been in use four years, one seven and one ten years, without repairs, but of the well seven years in use it was stated that its strainer was flushed occasionally. The records of the other wells may be summarized as follows:

Equitable Gas Co.—6 ins. diameter. Abandoned after six years "on account of corrosion and consequent leakage of pipe." New 6-in. well sunk about 2 ft. from first one. Depth (of each?), 387 ft.

Chickasaw Iron Works.—Originally 6 ins. diameter, telescoped to 3½ ins. after six years use. About 400 ft. deep.

Schlitz Brewing Co.—Telescoped after five years and finally abandoned. New 8-in. well sunk.

Gayoso Hotel.—6 ins. diameter, 450 ft. deep. "Now telescoped to 4 ins.; upper part of well leaking. Present well driven about seven years ago."

Court House.—8 ins. diameter, 366 ft. deep. "Sunk in 1891" and "now being fitted with a new pump tube, the old one having been so corroded that only one or two threads were left at the joints." Pipe ¼ in. thick.

Chickasaw Cooperage Co.—6 ins. diameter, 340 ft. deep. "Telescoped to 4½ ins. on account of muddiness of water." Period in use before telescoping not stated, but well said to have been "in operation about seven years."

In discussing the depreciation of the wells, Mr. Lundie says that the record of both the Artesian Water Co.'s and the "private wells throughout the city, point to a comparatively short life unless

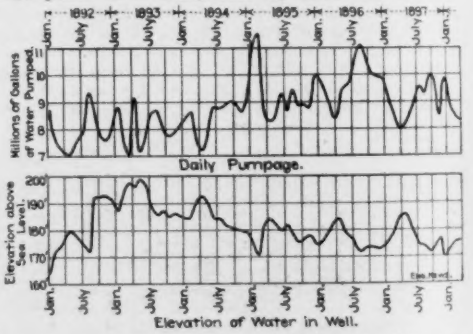


Fig. 4. Pumpage of Water from Memphis Wells and Elevation of Water in Pump-Well Stand-Pipe by Months, 1892-8.

prolonged by vigilant maintenance." The latter, he intimates, might well have been more liberal on the part of the company, but here again we must point out that this statement refers to past and not to recent conditions.

The percentage of depreciation is finally put at 10% for the wells lacking an outer casing, and 8% for those having one. The total depreciation of the wells up to April, 1898, was placed at 50%.

Fig. 4 shows the curves of pumpage and of elevation of water in the pump-well (or stand-pipe) from January, 1892, to March, 1898, inclusive, both by months.